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PHYSICS.—*The electrostatic field and the symmetry of snowflakes.*

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The symmetry of snowflakes has long evoked admiration and awe. Several theories have been advanced to account for snowflake production, but they are inadequate to explain the observed high degree of symmetry.[1, 2] This paper presents a new theory that attempts to account for both the observed symmetry of individual snowflakes and their infinite variation. It is not a complete theory of snowflake development, since it does not consider those environmental conditions which control the rate of snowflake growth and type of snow crystal formed. A thermodynamic analysis of the snow crystal's growth in its environment would be necessary to form a complete theory. Work in this field has been done by others.[1, 2] The theory presented is based on the observations of Nakaya in his comprehensive study of snow crystals.[1]

The snowflake is an oblate snow crystal whose most commonly observed form has symmetry corresponding to the two-dimensional group D_6—i.e., it has sixfold rotational symmetry and reflection about each dendrite. Occasionally snowflakes possessing symmetry corresponding to the groups D_2, D_3, and D_{12} (i.e., two-, three-, and twelvefold rotational symmetry and reflection about each dendrite, respectively) are observed, but they are variants of the more common D_6 variety. Many other varieties of snow crystals have been catalogued, and a correlation between the variety and environmental conditions existing at the time of their formation has been observed.

The keystone of the theory presented in this paper is that the rotational symmetry of the snowflake is maintained throughout its growth by means of its electrostatic field, which arises from a charge distributed over the surface of the snowflake. The snow crystal is assumed to be a relatively poor conductor (having a relaxation time of about 10^{-6} seconds). It attains its charge by the collection of ions generated in the atmosphere by cosmic ray bombardment.[3] The sign and magnitude of the charge on the snowflake probably vary greatly during its growth period (which may be several hours long). The sign of the charge is immaterial, but the magnitude controls the strength of several essential processes in the snowflake's growth. Only those snow crystals that develop under the special conditions that allow the charge on the crystal to play the dominant role in the symmetrical growth process will be considered in this paper. The majority of snow crystals are thus excluded: the highly symmetrical type forms only a minority of all snow crystals observed. Irregular snow crystals, having no symmetry, are formed when the environmental conditions are unfavorable to the special temperature, electrical, and water vapor requirements that favor the symmetrical development.

The snowflake acquires water for its growth in two ways; both are influenced by the electrostatic field. The first method is that of water vapor accretion. This method is based on the interaction of the water vapor molecule with the electrostatic

[1] *Snow crystals, natural and artificial*, Ukichiro Nakaya, Harvard University Press, 1954.

[2] MASON, B. J., *Snow crystals, natural and artificial*, Endeavor **10**(40): 205. October 1951.

[3] GUNN, R. *Electrification of precipitation and thunderstorms*, Proc. Inst. Radio Eng., **45**(10): 1331. October, 1957.

field of the snowflake. The water vapor molecule may be either neutral or charged. The neutral molecule will always be attracted because of the interaction of the large dipole moment of the water molecule and the electrostatic field.[4] The charged molecule will be attracted or repelled depending on the relative signs of the charge of the snowflake and the molecule. Water droplet accretion is the second method of growth. The water droplet may also be either neutral or charged. Neutral droplets may be acquired through the induced-dipole interaction with the electrostatic field of the snowflake or by direct collision. Charged droplets will be attracted or repelled depending on the relative signs of the snowflake and the droplet.

The suggested development of the snowflake will now be traced. The snowflake probably starts as a small right hexagonal prism of ice (about 0.001 mm in size) carrying an electric charge. At this stage, the water vapor molecule mode of accretion is probably most important because of the small geometrical cross section of the snowflake that presents itself for collision with water droplets, which are also about 0.001 mm in size. The forces on the molecule are greatest where the radius of curvature of the snowflake is smallest. Water vapor molecules are thus selectively attracted to the edges of the crystal. The water diffuses over the surface to an extent dependent on the temperature and the migration-inducing forces.

A neutral snow crystal would be expected to grow as a hexagonal prism, in conformity with crystal forces. The charge on the snowflake causes an additional factor to enter. The snowflake as a charged conductor has energy residing in its associated electrostatic field and will grow in such a manner that its electrostatic energy is as low as possible, with minor corrections due to crystal forces. The oblate form of the snowflake has a lower electrostatic energy associated with it than the prism form and thus the prism form is unstable.

In certain cases, however, the snowflake may develop as a prism until it is about 0.06 mm in size. Nakaya observes that at about this point the crystal will develop two observable hexagonal end plates. Only rarely will both plates compete successfully for the available water vapor and grow equally, leading to the rare snowflakes with D_{12} symmetry.

Usually, the snowflake will not grow very long in the unstable prism form, but will quickly assume the lower energy oblate form of the hexagonal plate. It will grow as a hexagonal plate as long as the surface diffusion process is dominated by the crystal forces. The electrical field, however, induces surface migration toward the vertices (opposite to the direction of migration caused by the crystal forces).[5] Also, the water vapor is electrically attracted to the vertices. These factors will act to cause the snowflake to begin to grow dendrites at each of its six vertices.

The snowflake now consists of a hexagonal center plate with six dendrites radiating from the vertices. While the tips of the dendrites will still grow by electrostatic interaction, the main process of accretion is probably now collision with water droplets. Nakaya observed that under conditions of snowflake production the droplet does not freeze where it contacts the snowflake. The charge content of the droplet distributes itself over the snowflake rapidly. If the thermodynamic conditions are favorable, the water content will have time to distribute itself in such a manner as to achieve a configuration with the lowest potential energy consistent with the snowflake's electrostatic field before it freezes. This distribution is another aspect of the electrostatically induced surface migration.[6]

Water collected as droplets or vapor at the interior of the snowflake will, under the influence of the electrostatic field, migrate to the nearest dendrite edge. An additional aspect of the electrostatic field now acts to maintain the symmetry of the den-

[4] POHL, H. A. *The motion and precipitation of suspenoids in divergent electric fields.* Journ. Appl. Phys. **22** (7): 869. July 1951.

[5] Field-induced surface migration is discussed in the review article by W. P. Dyke and W. W. Dolan, "Field Emission" appearing in Advances in Electronics and Electron Physics **8.** 1956.

[6] POHL, H. A. *Some effects of nonuniform fields of dielectrics.* Journ. Appl. Phys. **29** (8): 1182. Aug. 1958.

dritic structure. The water as a high dielectric liquid is acted upon by electrostrictive forces arising from the electrostatic field configuration of the snowflake. The fluid will migrate when there are forces that are tangential to the surface of the liquid. The edges of the dendrites are acted upon not only by their own charge distribution but also by that of all the other dendrite edges. (On the D_6 snowflake there are 12 such edges to consider.) The tangential forces on one dendrite edge arising from the charge distribution on another dendrite edge will be at a minimum when the adjacent edges are symmetrical in shape with respect to a reflection axis half way between them. The best symmetry is always achieved on an individual dendrite, with the center of the dendrite serving as the symmetry reflection axis. The radial bisector of the space between any two dendrites serves as another symmetry reflection axis. (There are a total of 12 symmetry reflection axes for the D_6 snowflake.)

Thus, any out-of-symmetry addition to the pattern on any dendrite will perturb the electrostatic field and create tangential electrostrictive forces which will cause the duplication of the addition in subsequent growth of the other dendrites. Of course, no single dendrite has a unique controlling influence; the process of perturbation and compensation is carried on continually on all dendrites.

The electrostatic field does not act to maintain equal length of the dendrites, but a uniform supply of water to all the dendrites will do so. If, however, the dendrites attain unequal radii, the electrostatic field acts to attain a lower order of symmetry. This action accounts for the occasional observance of D_3 and D_2 symmetry in snowflakes.

The infinite variety of snowflakes is caused by the random accretion of water on the dendrites in the atmosphere.

Admittedly, much research must be done to test the different aspects of this theory of snowflake production. It should be pointed out that the general mechanism of snowflake production as outlined above cannot be tested by growing crystals of hexagonal symmetry from solutions because of the absence in these situations of the all-important role played by the electrostatic field.

Summary.—The basic assertion of the theory here presented is that the electrostatic field of the charged snow crystal has a controlling influence on the shape of the crystal during its growth. The influence of the electrostatic field is exerted through field-induced surface migration, which causes symmetrical growth as the continuous lowest energy state. The theory takes into account the observed variations in sign and magnitude of the charge on snowflakes. The mode of development of snowflakes having shape symmetry corresponding to the two-dimensional rotation group D_6, as well as to the less commonly observed D_2, D_3, and D_{12} shapes, is indicated. The infinite variety of symmetrical forms is seen as resulting from the random nature of water accretion by the flake.

It is advisable here to make a remark which ought to be well considered by hasty observers. When a purely speculative discovery is announced to the public, it cannot be done with too much prudence. No one is obliged to discover either a planet, a comet, or a satellite; and whoever makes a mistake in such a case exposes himself justly to the derision of the mass.—From JULES VERNE'S *Around the Moon.*

MATHEMATICS.—*A new characterization of group.* HOWARD CAMPAIGNE, American University.

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V. V. Vagner has defined an "inverse semigroup" to be a semigroup for which for each element a there is a unique simultaneous solution to the equations $\begin{cases} axa = a \\ xax = x \end{cases}$ Since any solution to the single equation $axa = a$ implies a simultaneous solution to the two, it is a temptation to try to define the concept in terms of this single equation. To merely say it has a solution is too weak. To say it has a unique solution is too strong, for then the semigroup becomes a group. It is not possible to state Vagner's concept in terms of the one equation.

But the last observation is interesting in itself and gives a definition for group which is more compact than the standard one. It is: A group G is a set of elements $a, b, c, \cdots$ such that

I. It is a semigroup.

II. For each element a in G there is a unique element x in G such that axa = a.

To prove that this is equivalent to the usual definition, refer to page 16 of Carmichael. It is easily verified that the set described there satisfies the two conditions above. To prove the converse note that the element ax is idempotent, $axax = ax$. Now examine the element $y = xax$; notice that $aya = axaxa = axa = a$, so that by the uniqueness of II $y = xax = x$. Consider any idempotent e, $e^2 = e$; the subset eGe is closed under multiplication, and an element s is in eGe if and only if $es = s = se$. For any element g we have $ege = a$ is in eGe. Let x be the inverse of this a, $axa = a$; then $x = xax = xegex = xgx$ so that by the uniqueness of II $g = a = ege$ is in eGe, and it follows that $eGe = G$. If f is an idempotent then $ef = f = fe$ and $fef = f^2 = f$ and using the uniqueness of II again we have $e = f$. Thus e is the only idempotent of G, and for each element a there is the unique inverse x such that $ax = e = xa$, completing the proof.

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VAGNER, V. V. *Obobscennye gruppy.* Doklady Acad. Nauk SSSR **84:** 1119–1122. 1952.

In respect to other things there may be times of darkness and times of light, there may be risings, decadences, and revivals. In science there is only progress. . . . What is gained by scientific inquiry is gained forever; it may be added to, it may seem to be covered up, but it can never be taken away.—Sir MICHAEL FOSTER.

BOTANY.—*Two species of* Hibiscus *from Texas.* S. F. BLAKE, New Crops Research Branch, U. S. Department of Agriculture.

(Received August 5, 1958)

Ivan Shiller, of the Pink Bollworm Section, Entomology Research Division, has been interested in host plants of the pink bollworm (*Pectinophora gossypiella* Saund.), one of the greatest insect enemies of the cotton plant, since it was first found out-of-doors in the United States at Hearne, Tex., in 1917, and since 1940 he has devoted himself particularly to the collection of these hosts. Study of his Texas herbarium material of *Hibiscus*, the most important host genus for this insect aside from *Gossypium*, has brought to light one very distinct new species, at present known only from a single locality in Trinity County, and another species, found earlier by other collectors, which has been misidentified as *H. lasiocarpos* Cav. or *H. lambertianus* H.B.K. but which proves to be identical with a species (*H. cubensis* A. Rich.) described from the vicinity of Habana, Cuba, where it is now rare or perhaps extinct.

Hibiscus dasycalyx Blake & Shiller, sp. nov.

Herba perennis 1.5 m alta; caulis glaberrimus; folia paene usque ad basin hastate 3-partita petiolata glaberrima, segmentis linearibus attenuatis serratis interdum ad basin incisis saepe 4–8 cm longis 3–6 mm latis; flores 6–7 per caulem in axillis superioribus solitarii; pedunculus supra patenti-hirsutus prope medium articulatus ca. 1.5 cm longus; bracteoli ca. 12 anguste lineares attenuati intus et margine dense hirsuti extra sparse hirsuti v. subglabri ca. 1.5 cm longi 1–1.5 mm lati calyce ca. ¼ breviores; calyx ca. 2.5 cm longus campanulatus extra densissime albido-hirsutus intus densissime flavescenti-pilosus pilis subappressis, lobis deltoideis ca. 7 mm longis apiculatis; corolla alba purpureo-oculata sicc. ca. 6 cm longa prope apicem patens; ovarium dense et subappresse flavescenti-pilosulum.

Herb 1–1.5 m high; stem greenish, terete, 3 mm thick above; upper internodes mostly 3–5 cm long; petioles slender, 3–5 cm long; leaf blades 5–9 cm long, about 3–10 cm wide at base across the lobes, divided to within 2–4 mm of the top of the petiole, rather light green above, still lighter beneath, the lobes sometimes entire toward base, sometimes incised there, serrate above, the teeth mostly 3–15 mm apart; styles free above and there pilose; fruit unknown.

TEXAS: Trinity County, west of the Neches River about 13 miles west of Lufkin (which is in Angelina County), June 23, 1955, *Ivan Shiller* 231 (type no. 2261376, U.S. Nat Herb.).

This very distinct species is allied to *H. coccineus* Walt. and *H. militaris* Cav., having leaves much like those of the former species and corolla more like that of the latter, but it is at once distinguished from both and from all other United States species by its densely spreading-hirsute calyx.

Hibiscus cubensis A. Rich. in de la Sagra, Hist. Fis. Polit. y Nat. Cuba, 2. pt. Hist. Nat., **10** (Botánica): 51. 1845.

Herbaceous perennial, up to 3 m high, densely gray-velutinous throughout except on corolla (including both surfaces of leaves and of calyx) with short stellate hairs; stem, sometimes also the petioles and peduncles, remotely or rather densely aculeate with straight spreading at length corky-based prickles 3 mm. long or less, these densely short-hairy below, glabrous above and tipped with a deciduous bristle, the prickles apparently sometimes lacking; petiole 2–6 cm long, mostly ⅓–½ as long as blade; leaf blades oblong or ovate-oblong, 8–11 cm long, 3.5–5 cm wide, acute to acuminate, at base subtruncate to shallowly cordate, crenate-serrate on margin throughout, papery, mostly 5-nerved with the 2 lateral pairs of veins much weaker than the median one, not at all or only obscurely greener above than below; peduncles solitary in the upper axils, 2-(fruit) 3.5 cm long, jointed almost at the base; bractlets about 12, narrowly linear or in age somewhat involute-margined and linear-filiform, 1.2–1.5 cm long, 0.5–1.5 mm wide, sometimes sparsely hispid as well as densely velutinous, erectish, in age reflexed; calyx in flower 2.5–2.8 cm, at maturity about 3.2 cm high, sometimes more or less hispid outside especially on the nerves, the broadly triangular acuminate teeth about equalling the tube; corolla 8–9 cm long, "purple

or orchid with dark reddish blotch," the petals with spreading tips; capsule subglobose, abruptly apiculate (apiculus 1 mm long), densely spreading-hispid outside with ochroleucous hairs and between them minutely hispidulous, glabrous inside; seeds densely and shortly rufescent-velvety, 2.5 mm long; styles united to apex; stigmas oblong.

CUBA: Banks of Laguna Majana, Havana, Oct. 31, 1918, *Bro. León et al.* no. 8485, and Dec. 5, 1918, no. 8516 (both in herb. N.Y. Bot. Gard.). TEXAS: Midfield, Matagorda County, July 23, 1927, *B. C. Tharp* 4743 (U.S. Nat. Herb.); Calhoun County, Aug. 15, and Oct. 3, 1953, *I. Shiller* 251 (U.S. Nat. Herb.); cultivated (from last locality),

FIG. 1.—*Hibiscus dasycalyx*. Plant and corolla, ×½; calyx (including inside view), about ×⅓.

Brownsville, *Shiller* (U.S. Nat. Arb.); Tivoli, Refugio County, Aug. 14, 1939, *G. L. Fisher* 39104 (U.S. Nat. Herb.).

The Cuban material was identified by N. L. Britton as *Hibiscus lambertianus* H.B.K., and the late Dr. T. H. Kearney, to whom I sent a sheet of Shiller's material not long before his death, returned it la-

FIG. 2.—*Hibiscus cubensis*. Plant, capsule, seeds, calyx, corolla, and inside view of calyx; all ×½ except the magnified view of seed, which is ×4. From Shiller 251 and Fisher 39104.

belled doubtfully as this species. *Hibiscus lambertianus* H.B.K., of which the U.S. National Herbarium possesses a number of sheets from North and South America as well as a photograph of the type (from Guigui, Aragua Valley, Venezuela), has the leaves green and sparsely stellate-pubescent above and sparsely or sometimes densely so (but never velutinous), consequently green or dull grayish beneath, as well as essentially glabrous to lightly stellate-puberulent stems. Although evidently allied to *H. cubensis*, it is surely distinct from the latter, which is at once recognizable by the dense and essentially uniform velvety pubescence on all parts of the plant except the corolla.

In the Flora de Cuba (**3**: 255. 1953), Brother Alain calls this plant *H. lambertianus* H.B.K. and places *H. cubensis* A. Rich. and *H. sagraeanus* Merc. under it as synonyms. I consider the name *H. sagraeanus* Merc. (Bull. Bot. Seringe **1**: 169. 1830), too dubious to adopt in place of the later *H. cubensis* A. Rich. Mercier's description agrees in most respects with *H. cubensis*, but his description of the pubescence, the strongest distinctive character of *H. cubensis*, does not fit too well. He says the branches are glabrous below, pubescent and spiny above, and that the oblong-lanceolate leaves are green above and gray beneath, pubescent or muricate (pubescentia muricatave) on both sides with very numerous short soft hairs mixed with more rigid 3-furcate hairs, the nerves beneath more rufescent-pilose.

GYROMAGNETIC RATIO OF PROTON REDETERMINED

The gyromagnetic ratio of the proton—a measure of its interaction with magnetic fields—has been redetermined by the National Bureau of Standards with significant increase in accuracy. This result not only provides a better standard for magnetic fields but also makes possible more accurate values for many of the fundamental constants of physics whose values depend upon magnetic field measurements. Examples are the electron charge-to-mass ratio e/m, the magnetic moment of the proton, and Planck's constant h.

The redetermination was made by R. L. Driscoll and P. L. Bender of the Bureau staff using facilities provided by the Fredericksburg Magnetic Observatory of the U. S. Coast and Geodetic Survey.

The new value for the proton's gyromagnetic ratio will be especially useful in the design and development of scientific and industrial apparatus in which it is important to know accurately the spatial distribution of a magnetic field or to regulate it closely. Here the proton can be used as a very sensitive probe to determine magnetic intensity in terms of the precisely known gyromagnetic ratio. Problems of this sort arise widely in the use of scientific apparatus—cyclotrons, mass spectrographs, and beta-ray spectrometers—and in industrial equipment such as servo mechanisms and electromagnets.

The present work was carried out as part of a broader program which seeks to obtain more accurate values for important constants, such as the speed of light, the acceleration of gravity, and the various atomic constants. These constants of nature, when determined to extremely high accuracy, provide invariant bases for the reproduction standards of many physical quantities such as length, time, and electric current. They thus serve to lock present standards and units of physical measurement into the phenomena of science. Because the proton's gyromagnetic ratio is theoretically related to many of these constants, it provides a connecting link between them and the accepted standards of measurement.

Like other atomic nuclei, the proton, or hydrogen nucleus, behaves as a small magnet. When placed in a magnetic field, it tends to orient its axis along the direction of the field. However, the proton is also spinning rapidly about its axis, and the resulting angular momentum causes it to act like a gyroscope. Thus, instead of lining up with the field, the proton actually precesses about the field direction.

The ratio of the angular precession frequency to the magnetic field strength gives the gyromagnetic ratio.

In 1949 H. A. Thomas, R. L. Driscoll, and J. A. Hipple made the first precise measurement[1] of the proton gyromagnetic ratio, using as protons the hydrogen nuclei contained in a small water sample. Their result was combined with other data to give a more precise absolute value for the proton magnetic moment than had previously been possible. More accurate values were also obtained for a number of the fundamental constants of physics, such as the electron charge-to-mass ratio and Planck's constant.

In the 1949 measurement, the gyromagnetic ratio was determined by measuring the magnetic field and radio frequency required for magnetic resonance absorption in the proton sample. A strong magnetic field of about 5000 gausses was used, and its value was determined by finding the force exerted by the magnetic field on a wire carrying a known current. This magnetic field measurement was difficult and was the principle limitation on the accuracy of the result obtained.

The present method reduces the error of the earlier one by a factor of four by using simpler techniques that have been developed since 1949. In this method the hydrogen protons in a water sample are caused to precess in a magnetic field, and the precession rate is obtained from the frequency of the voltage induced in a pickup coil surrounding the sample. The gyromagnetic ratio is then obtained as the ratio of the angular precession frequency to the field strength.

Increased accuracy is obtained by using a magnetic field that can be calculated to very high precision. This field is produced by an accurately measured current flowing through a solenoid whose important dimensions are known to one part in a million. However, as the field strength obtained in this way is only 12 gausses, spurious magnetic fields from other apparatus, electrical currents, or vehicles must be carefully avoided. For this reason, the measurements have been carried out at the Fredericksburg Magnetic Observatory of the U. S. Coast and Geodetic Survey. The Observatory is about 10 miles south of Fredericksburg, Virginia, on a site chosen to be as free as possible from magnetic field disturbances. A separate nonmagnetic building, with large coils for compensating the earth's magnetic field, was made available for the experiment. At this location man-made magnetic field fluctuations are negligible and corrections for variations in the earth's field can be obtained from the Observatory magnetograms.

The proton sample consists of distilled water contained in a glass sphere about 2 cm in diameter. The sample is placed in a strong magnetic field in order to build up a large magnetization of the protons along the direction of the magnetic field. It is then shot about 15 meters through a pneumatic tube into the center of the solenoid, within the nonmagnetic building. With the sample in the solenoid, a short pulse of radio-frequency magnetic field near the precession frequency is applied to tip the magnetic moments of the protons so that they are left nearly perpendicular to the magnetic field direction. They then precess about the magnetic field direction at a frequency corresponding to the strength of the field. The flux through a pick-up coil surrounding the sample changes at the same frequency at which the magnetization of the sample is precessing. The frequency of the induced voltage across the pick-up coil is measured accurately against standard frequency broadcasts by the Bureau's radio station, WWV, and the resulting value is combined with the magnetic field strength to give the proton gyromagnetic ratio.

A preliminary value of $(2.67515 \pm .00001) \times 10^4$ radians/(sec gauss), uncorrected for diamagnetism of the water sample, was obtained for the proton gyromagnetic ratio in terms of the ampere as now maintained at the Bureau. The value obtained in 1949 was given as $(2.67523 \pm 0.00006) \times 10^4$ radians/(sec gauss). If the present result is combined with a recent determination[2] by Driscoll and Cutkosky of the ampere as maintained at the Bureau in absolute units, the value becomes $(2.67513 \pm .00002) \times 10^4$ radians/(sec gauss).

[1] *Measurement of the proton moment in absolute units*, by H. A. Thomas, R. L. Driscoll, and J. A. Hipple. Journ. Res. NBS **44**: 569. 1950. RP2104; see also *Magnetic moment of the proton*, NBS Tech. News Bull. **33**: 57. May 1949.

[2] *Measurement of current with the NBS current balance*, by R. L. Driscoll and R. D. Cutkosky. Journ. Res. NBS **60**: 4. 1958. RP 2846; *Measurement of current with a Pellat type electrodynamometer*, by R. L. Driscoll, Journ. Res. NBS **60**, 4. 1958. RP 2845; *Redetermination of the standard ampere*, NBS Techn. News Bull. **42**, 21 February 1958.

BOTANY.—*Notes on South American phanerogams—I.* LYMAN B. SMITH, Department of Botany, U. S. National Museum.

(Received August 5, 1958)

The present notes are largely an effort to provide names for certain of my own collections obtained in southern Brazil in 1956–57 with the help of a grant from the National Science Foundation. However, it has been possible to include some items from other countries that would be too small to publish by themselves. Dr. Robert J. Downs of the Plant Industry Station, U. S. Department of Agriculture, has joined me in proposing names that were the outcome of our joint studies, and has prepared the illustration.

Family XYRIDACEAE

Xyris subuniflora Malme, Rec. Trav. Bot. Néerl. **9:** 129. 1912.

Xyris capillaris Steyermark, Fieldiana, Bot. **28,** no. 1: 107. 1951. Not Malme, Ark. Bot. **24A,** no. 5: 8. 1932.

Guiana, Venezuela, Colombia.

Family LILIACEAE

Herreria Ruiz & Pavon, Fl. Peruv. & Chil. Prodr. **48,** *pl. 35.* 1794.

The following synopsis is the byproduct of identifying certain Brazilian specimens in the United States National Herbarium and does not pretend to be a revision of the genus. However, it does account for all names whether of valid species or of synonyms.

KEY

1. Capsule horizontally ridged, retuse, broader than long; leaves linear, coriaceous, glaucous, densely and strongly nerved, the margins revolute; tepals 5–6 mm long; plant caulescent. Chile.....**1. H. stellata**
1. Capsule even, truncate or rounded or (where not known) the leaves much broader than linear. Brazil, Uruguay, Paraguay, Argentina.
2. Plant long-caulescent, scandent; inflorescences lateral.
3. Inflorescence glabrous.
4. Leaves not over 9 mm. wide; capsule higher than wide; anthers not over 1.3 mm long; tepals not over 4 mm long **2. H. montevidensis**
4. Leaves to 35 mm. wide; capsule wider than high (unknown in *H. glaziovii*).
5. Stem aculeate especially toward base; anthers scarcely more than 1 mm. long; tepals 5–6 mm. long, green. **3. H. salsaparilha**
5. Stem unarmed; anthers 2.5 mm. long; tepals 4–5 mm. long, brown. **4. H. glaziovii**
3. Inflorescence hispidulous.
6. Branches of the inflorescence alternate. **5. H. latifolia**
6. Branches of the inflorescence opposite or verticillate or the inflorescence simple. **6. H. interrupta**
2. Plant stemless, erect; inflorescence terminal.
7. Scape naked; inflorescence branched, the branches strict.....**7. H. stricta**
7. Scape bracteate; inflorescence simple. **8. H. ophiopogonoides**

1. **Herreria stellata** R. & P. Fl. Peruv. & Chil. **3:** 69, *pl. 303.* 1802.

Herreria verticillata Molina, Sagg. Chile, ed. 2. 136. 1810.

This species from the vicinity of Concepción in south-central Chile is the type of the genus.

2. **Herreria montevidensis** Kl. ex Griseb. in Mart. Fl. Bras. **3,** pt. 1: 24. 1842.

Paraguay, northern Argentina, southern Brazil, Uruguay.

2a. **Herreria montevidensis** var. **montevidensis** Leaves mostly 4–9 mm wide.

2b. **Herreria montevidensis** var. **bonplandii** (Lecomte) L. B. Smith, comb. nov.

Herreria bonplandii Lecomte, Bull. Soc. Bot. France **56:** 346. 1909.

Herreria tuberosa Rojas, Bull. Géogr. Bot. **28:** 158. 1918.

Dioscorea tuberosa Rojas, Bull. Géogr. Bot. **28:** 158. 1918. In synonymy.

Herreria linearifolia U. Dammer, nomen. Field Museum photo no. 10005.

Leaves mostly 3 mm wide or less. This narrow-leaved variety appears to intergrade with the typical one but is so striking that it needs some designation.

3. **Herreria salsaparilha** Mart. in Spix & Mart. Reise Bras. **1:** 545. 1823; Schultes, Syst. Veg. **7:** 363. 1829; Griseb. in Mart. Fl. Bras. **3,** pt. 1: 23, *pl. 4, 5.* 1842.

Herreria parviflora Lindl. Bot. Reg. **12:** *pl. 1042.* 1827.

Rajania verticillata Vell. Fl. Flum. Icon. **10:** *pl. 115.* 1835; Arch. Mus. Nac. Rio de Janeiro **5:** 424. 1881.

Herreria brasiliensis Hort. Berol. ex Kunth, Enum. **5:** 294. 1850. In synonymy.

Herreria grandiflora Griseb. Kjoeb. Vidensk. Meddell. 152. 1875.

Herreria verticillata (Vell.) Stellfeld, Trib. Farm. Curitiba **12:** 133. 1944. Not Molina, 1810.

Eastern Brazil from Bahia to Minas Gerais and Rio de Janeiro. There is some possibility that more material will show a distinction between *H. salsaparilha* of Bahia and *H. parviflora* of Rio de Janeiro.

4. **Herreria glaziovii** Lecomte, Bull. Soc. Bot. France **56:** 347. 1909; L. B. Smith, Contr. Sci. Los Angeles County Mus. no. **23**: 4. 1958.

Southern Goiás in central Brazil.

5. **Herreria latifolia** Woodson, Ann. Missouri Bot. Gard. **37:** 397. 1950.

Western Minas Gerais, Brazil.

6. **Herreria interrupta** Griseb. in Mart. Fl. Bras. **3,** pt. 1: 24. 1842.

Herreria salsaparilha var. *"H." interrupta* Baker, Journ. Linn. Soc. **18:** 232. 1880.

São Paulo, Brazil. The type of the species is a *Sellow* collection (B) without locality data and in rather poor flowering condition (Field Museum photo no. 10004). *Novaes* 1144 (US) is from Campinas, São Paulo, thus localizing the species. *Widgren* s.n. (US), doubtfully noted as from Minas Gerais, is in fruit and has both simple and branched inflorescences, indicating that this distinction is of no value here. The capsule is very short and broad as in *H. salsaparilha*.

7. **Herreria stricta** L. B. Smith, sp. nov. FIGS. a, b

Acaulis, florifera metralis; foliis strictis, linearibus, acuminatis, 12 cm longis, 7 mm latis, dense valdeque nervatis; scapo 3 mm diametro, ebracteato, sulcato; inflorescentia pauciramosa, glabra; ramis strictis, gracilibus, ad 21 cm longis; bracteis ovatis, acutis, quam pedicellis subduplo brevioribus; pedicellis gracilibus, fructiferis ad 6 mm longis; floribus ignotis; capsulis late oblongo-ellipticis, late rotundatis apiculatisque, 15 mm longis.

Type in the U. S. National Herbarium, no. 1573005, collected in campo, Estancia Primera, Apa, Paraguay, by Pedro Jorgensen (no. 4758).

8. **Herreria ophiopogonoides** (Kunth) Niederlein, Bol. Mens. Mus. Prod. Argent. **3,** no. 31: 334. 1890.

Clara ophiopogonoides Kunth, Enum. **5:** 296. 1850.

Southern Brazil, northeastern Argentina, Uruguay. I am indebted to Dra. Nélida S. T. de Burkart of the Instituto de Botánica Darwinion for verification of the Niederlein reference.

Family CUNONIACEAE

Lamanonia Vell. Fl. Flum. 228. 1825; Icon. **5:** *pl. 104.* 1835; O. Kuntze, Rev. Gen. **1:** 227, 1891.

Belangera Camb. Cunon. Syn. in St.-Hil. Fl. Bras. Merid. **2:** 204. 1829; Engler in Mart. Fl. Bras. **14,** pt. 2: 151. 1871; Pflanzenfam. ed. 2. **18a:** 229. 1930; Pampanini, Annali di Bot. **2:** 52. 1905.

The name *Belangera* has not been conserved and there is no doubt of the identity or priority of *Lamanonia*. Therefore it is difficult to understand how Engler could have been following the International Rules of Botanical Nomenclature in using *Belangera* as late as 1930.

Lamanonia ternata Vell. Fl. Flum. 228. 1825; Icon. **5:** *pl. 104.* 1835.

Belangera glabra Camb. Cunon. Syn. in St.-Hil. Fl. Bras. Merid. **2:** 204, *pl. 115.* 1829.

Lamanonia glabra (Camb.) O. Kuntze, Rev. Gen. **1:** 227. 1891. Not Vell. 1825.

Both the description and plate of *Lamanonia ternata* indicate three-foliolate leaves as does the specific name itself. Yet it has always been equated with *Belangera speciosa*, a species that is consistently five-foliolate.

Lamanonia speciosa (Camb.) L. B. Smith, comb. nov.

Belangera speciosa Camb. Cunon. Syn. in St.-Hil. Fl. Bras. Merid. **2:** 206, *pl. 117.* 1829.

Lamanonia ternata sensu O. Kuntze, Rev. Gen. **1:** 227. 1891. Not Vell. 1825.

Lamanonia chabertii (Pampanini) L. B. Smith, comb. nov.

Belangera chabertii Pampanini, Ann. Conserv. & Jard. Bot. Genève **7–8:** 328. 1904; Engler, Pflanzenfam. ed. 2. **18a:** 236. 1930.

Lamanonia ulei (Engler) L. B. Smith, comb. nov.

Belangera ulei Engler, Pflanzenfam. ed. 2. **18a:** 236. 1930.

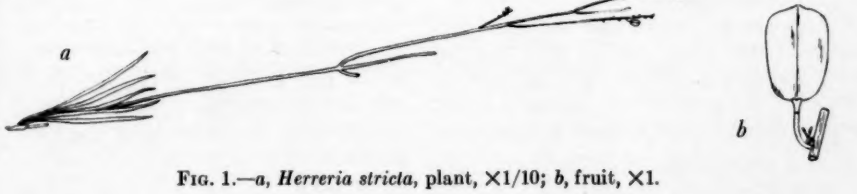

FIG. 1.—*a, Herreria stricta*, plant, ×1/10; *b*, fruit, ×1.

Family CONVOLVULACEAE

Ipomoea delphinoides Choisy, Conv. Rar. 131. 1838; Mém. Soc. Phys. Genève **8,** pt. 1: 53. 1838; DC. Prod. **9:** 352. 1845; O'Donell, Lilloa **23:** 480. 1950. In adnot.

Convolvulus campestris Vell. Fl. Flum. 74. 1825; Icon. **2:** *pl. 66.* 1835. Not *Ipomoea campestris* Meissn. in Mart. Fl. Bras. **7:** 254. 1869.

Ipomoea trifurcata Choisy, Conv. Rar. 131. 1838; Mém. Soc. Phys. Genève **8,** pt. 1: 53. 1838; DC. Prod. **9:** 352. 1845; O'Donell, Lilloa **23:** 480. 1950. In adnot.

Ipomoea polymorpha Riedel ex Meissn. in Mart. Fl. Bras. **7:** 252. 1869. Not R. & S. Syst. Veg. **4:** 254. 1819.

Two names published on the same page, *Ipomoea delphinoides* and *I. trifurcata* were available for this species, and O'Donell chose *I. delphinoides*. This widely distributed species of southern Brazil is commonly found in the herbarium under the name of *I. polymorpha*.

Family RUBIACEAE

Borreria G. F. W. Meyer Section **Galianthe** K. Schum. in Mart. Fl. Bras. **6,** pt. 6: 41. 1888; Standl. Field Mus. Pub. Bot. **8:** 393. 1931.

Galianthe Griseb. Goett. Abh. **24:** 156. 1879. First valid publication.

Section *Galianthe* of *Borreria* is characterized by its cymose inflorescences and dichogamous flowers and is limited to southern Brazil and closely adjacent areas. K. Schumann arranged the species largely according to the form of the style, a character which could be expected to vary widely in dichogamous flowers. Standley noted this in the discussion following his *B. luteovirens* (Field Mus. Publ. Bot. **8:** 393) but failed to follow out his own line of reasoning and continued to identify and cite material of this section obviously using a process of matching. Once the character of the style is discarded there is nothing of significance to separate *B. fastigiata* and *B. leiophylla* or *B. verbenoides* and *B. valerianoides*.

Borreria fastigiata (Griseb.) K. Schum. in Mart. Fl. Bras. **6,** pt. 6: 68. 1888.

Galianthe fastigiata Griseb. Goett. Abh. **24:** 157. 1879.

Borreria leiophylla K. Schum. in Mart. Fl. Bras. **6,** pt. 6: 66. 1888.

The species is characterized by even, presumably rather fleshy, leaves with faint or wholly obscured lateral nerves, a glabrous inflorescence, and short broadly triangular sepals.

Borreria laxa var. **vestita** Smith & Downs, var. nov.

Borreria paraguariensis Chodat & Hassler, Bull. Herb. Boiss. II. **4:** 186. 1904.

Borreria valerianoides sensu Smith & Downs, Sellowia no. **7:** 79, *pl. 28, figs. h, i.* 1956. Not Cham. & Schlecht. 1828.

Inflorescentia plus minusve vestita.

In our treatment of the Rubiaceae of Santa Catarina, Dr. R. J. Downs and I laid too much emphasis on indument and confused *Borreria laxa* with *B. valerianoides*. Actually *B. laxa* is well distinguished by its irregular inflorescences, broad thin leaves, and curving stem. Herbarium material indicates that it is probably somewhat scandent.

Borreria verbenoides Cham. & Schlecht. Linnaea **3:** 331. 1828.

Var. **verbenoides**

Borreria valerianoides Cham. & Schlecht. Linnaea **3:** 335. 1828.

Borreria thalictroides K. Schum. in Mart. Fl. Bras. **6,** pt. 6: 71. 1888.

Corolla glabrous, remainder of the inflorescence glabrous to sparsely vestite.

Var. **eupatorioides** (Cham. & Schlecht.) Smith & Downs, comb. nov.

Borreria eupatorioides Cham. & Schlecht. Linnaea **3:** 327. 1828.

Borreria centranthoides Cham. & Schlecht. Linnaea **3:** 328. 1828.

Corolla vestite, remainder of the inflorescence densely vestite until after anthesis.

Hedyotis dusenii (Standl.) Smith & Downs, comb. nov.

Oldenlandia dusenii Standl. Field Mus. Pub. Bot. **8:** 343. 1931. Brazil: Paraná, Santa Catarina, Rio Grande do Sul.

Psychotria carthaginensis Jacq. Enum. Pl. Carib. 16. 1760; Sel. Stirp. Amer. *pl. 174, fig. 22.* 1763; Standl. Field Mus. Bot. **13,** pt. 6: 183, 187. 1936; N. M. Bacigalupo, Darwiniana **10:** 34, *fig. 1.* 1952; A. L. Cabrera, Man. Fl. Alrededores de Buenos Aires 446. 1953.

Psychotria alba R. & P. Fl. Peruv. **2:** 58, *pl. 205, fig. a.* 1799; Standl. Field Mus. Bot. **13,** pt. 6: 182. 1936; Smith & Downs, Sellowia no. 7: 50, *pl. 14, figs. a–e.* 1956.

After using *P. alba* in our Rubiaceae of Santa Catarina we are forced to admit that the line between subsessile flowers in *P. carthaginensis* and short-pedicellate ones in *P. alba* is too dim to follow.

Psychotria vellosiana Benth. Linnaea **23:** 464. 1850.

Coffea sessilis Vell. Fl. Flum. 64. 1825; Icon. **2:** *pl. 20.* 1835. Not *Psychotria sessilis* Vell. 1825.

Psychotria axillaris Vell. Fl. Flum. 67. 1825; Icon. **2:** *pl. 32.* 1835. Not Willd. 1798.

Psychotria sessilis (Vell.) Muell. Arg. in Mart. Fl. Bras. **6,** pt. 5: 358. 1881. Not Vell. 1825.

In using the Flora Brasiliensis for making identifications, botanists have generally overlooked the fact that *Psychotria sessilis* (Vell.) Muell. Arg. is a later homonym and must be replaced by *P. vellosiana* Benth.

ZOOLOGY.—*Trends and problems in pelecypod classification (the genus and subgenus)*. DAVID NICOL, Southern Illinois University, Carbondale, Ill.

(Received August 26, 1958)

Many of the ideas set forth in this paper are not original, and the application and manipulation of certain data are, at least in part, not new. However, it is certainly true that many of them are little known and have been overlooked by the present generation of taxonomists. The reason for this seems to be that while the thoughts and writings of certain workers are widely read and often accepted without question, others are ignored or forgotten. It behooves us all to examine the data and ideas of some of the less-known or less generally accepted workers in taxonomy and evolution, for even if we do not agree with their conclusions we may gain a new insight into some of our present problems.

CONCEPT AND SCOPE OF THE GENUS AND SUBGENUS

The essence of classification is the grouping of animals on the basis of their relationship to one another, the genus or subgenus being the lowest taxonomic category for the grouping of related species. It is unfortunate that the lack of proper grouping, among other causes, has led to so much splitting of pelecypod genera and subgenera that the genus is no longer a pragmatic category in preliminary identification of specimens; that is to say, pelecypod specimens must first be pigeon-holed as to family because the identification of finely delineated genera is often not possible at first glance.

It is acknowledged, of course, that difficulties of pelecypod classification stem not only from the minute delineation of genera but also from the size of the entire class.

From the standpoint of described living species, the phylum Mollusca is a comparatively large one. I say comparatively large because it is not more than one-tenth the size of the Arthropoda. Malacologists doing taxonomic work estimate that there are nearly 100,000 described living species. About three-fourths of these are gastropods, and most of the remainder (around 20,000) are pelecypods. The class Pelecypoda is a prominent fossil group throughout all but the early part of its geologic history (Ordovician to Recent). Nearly 8,000 generic and subgeneric names have been proposed in the class during the past two centuries, in striking contrast to Linné's original establishment of a mere 15 genera (including *Teredo*, which Linné did not recognize as a pelecypod). The number is steadily increasing. For instance, a cursory examination of the *Zoological Record* for the five-year period of 1950 through 1954 reveals that the average number of new genera and subgenera proposed annually is 23. (The actual number is probably slightly higher than this for reasons that need no explanation.) The proposals of new genera and subgenera were made by relatively few taxonomists during this 5-year period.

There have been a few complaints in recent years concerning the number of new genera and subgenera proposed for mollusks. Perhaps the most recent is that of Burch (1956, p. 144). Earlier, Cotton and Godfrey (1938, in their authors' preface) made the following statement:

> Here we may note that if all the so-called genera introduced and available for South Australian shells were used, there would be very few genera with more than one or two species. We have endeavoured to steer a middle course. For the purposes of this handbook, we have used the stronger forms of subgenera as full genera, and wholly discarded the weaker ones.

And still earlier, Grant and Gale (1931, p. 88) made the following assertions:

> One extreme is the old Linnean policy of classing the whole of the mollusca under a score or two of genera; the other extreme is to have a genus for every species. There is something to be said for the former extreme, for a few names are easy to remember and to use and they divide the class into two [sic] groups each of which is easier to handle as a unit than the whole class. Nothing can be said in favor of the latter extreme, for it is the equivalent of discarding generic names altogether and making specific names twice as long

and more than twice as hard to handle. The Linnean system was meant to be binomial, and to be most useful the generic name was meant to be markedly different in breadth of application from the specific. Even a generic name for every well-marked species is almost obviously too close to the more unreasonable of the two extremes, for it makes the nomenclature too cumbersome, with too many names, all apt to be involved in nomenclatorial, time-wasting difficulties. Besides, the genera are needed for showing broader relationships, and the unit of the well-marked species and its close or doubtfully distinct relatives can be handled more satisfactorily in other ways.

Grant and Gale continued in this vein on p. 89.

It is a true, though very unfortunate, circumstance that arguments in justification of a multiplication of names are too often merely a form of ratiocination engendered, usually subconsciously, by a desire for the supposed glory of being author of the new names. During times when the multiplication of names is popular, many writers indulge in it as a sort of speculation not unlike speculative inflation of the stock market, and the process keeps on until the market is glutted with such securities and deflation and hard times ensue, it not a nomenclatorial panic, followed by a gradual return to a more reasonable intermediate position. Such fluctuations are costly in wasted energy, and it is better for science not to speculate too much in this way.

There have been a few additional doubters as to the good that continual splitting of genera will do for the classification of the Mollusca, but these few outcries of caution have done little or nothing to stem the flood of new generic and subgeneric names.

On the other hand, there are many taxonomists who give reasons for splitting genera and subgenera of mollusks. Only a few of them will be reviewed here.

One of the biologically least sound reasons for generic splitting was plainly stated by Crickmay (1932, p. 445) in his work on the Trigoniidae.

In the first place, the number of species is now so large, there being about 900 of them, that to retain *Trigonia* as a comprehensive genus defeats the prime object of classification, as it did with "*Ammonites*" and "*Belemnites*".

Simpson (1945, p. 16) rebuts Crickmay with the following statement:

The practical classifier grants to a genus a certain "size," by which is meant, as a rule, a certain morphological scope, with the implication that this scope tends to approximate a certain degree of phylogenetic differentiation, to include all animals related to each other within certain limits. This morphological scope may be almost entirely filled or exploited by known species if the genus has many (is polytypic), or only one or a few species may be known, leaving much of the assigned scope blank.

It seems clear that Crickmay did not have in mind the concept of size as expressed by Simpson when he suggested the splitting of *Trigonia*. Crickmay's idea of size is the one generally expressed by taxonomists of the Mollusca—mere number of species, regardless of morphologic scope.

Crickmay's other reasons for splitting the genus *Trigonia* are certainly more valid and are as follows:

In the second place, the genus *Trigonia*, as formerly conceived, is an incongrous one: certain of the groups which it comprises, for instance, Costatae and Clavellatae, are clearly distinct throughout their entire geologic history. Each one is very unlike the other, yet each bears resemblances to separate species among the ancestral genus *Myophoria* in the broad sense. In the third place, even the conservative characters of each of the many groups of species are so different as to merit nomenclatorial distinction. Lastly, a comparative view of taxonomic methods brings into evidence a great and undesirable discrepancy between the comprehensiveness of the genus *Trigonia* and the limitation of genera of other classes of animals.... Other families of pelecypods furnish excellent illustrations of the narrow limits assigned to genera by modern zoologists. For instance, some of the genera of the Veneridae differ only in the manner of shell ornament.

The last reason quoted above is not entirely supportable. The discrepancy between the comprehensiveness of some genera and the limitation of others, although regrettable, is not a sound basis for continuing an unwise practice. For example, it would be the height of taxonomic folly to split all families to the extent that the Inoceramidae have been split, merely to eliminate discrepancies in comprehensiveness.

Bartsch (1955, p. 5) in his paper on the Pliocene pyramidellids of Florida gives

the following reason for additional splitting:

> Since it is my belief that it will be easier for students to become acquainted with the members of smaller genera, I shall herein elevate some of the subgenera used by Dall and Bartsch to generic rank.

If Bartsch deems it necessary to study small groups, why can he not study them as subgenera? In raising their rank he has in no way diminished their size and has eliminated a useful category. Furthermore, he has defeated his own stated purpose (viz., making things "easier") by necessitating the students' becoming acquainted with more numerous genera and genera which, being more finely delimited, are more difficult to distinguish from one another. Nevertheless, in this same paper Bartsch proceeds to erect two new genera, one new subgenus, and one new pseudogenus, whatever that is.

Marwick (1957, p. 144) in his discussion of the Turritellidae has stated:

> The genus *Turritella*, as widely interpreted, comprises over 1,000 named species and subspecies, ranging in age from the Lower Cretaceous, perhaps Jurassic, to Recent, and distributed throughout the world. It is thus too comprehensive to be as useful in taxonomy, stratigraphy, or palaeogeography as it could be if more restricted.

I disagree with Marwick on the grounds that the splitting of genera solely for the sake of stratigraphy and paleogeography (paleobiogeography?) is not valid. Splitting should be based on the differentiation of distinct morphologic characters. Especially in the Paleozoic strata, a species, let us say, collected from Silurian strata is often allocated to one pelecypod genus, and a species very similar in all morphologic characteristics collected from undoubted Devonian strata is allocated to a different genus. To what genus does the stratigrapher allocate the species if he is not certain whether he is dealing with Silurian or Devonian strata? This whole idea strongly smacks of Werner's catastrophism.

Here again the application to stratigraphy comes to the fore. Among the most notorious "splitters" have been the paleontologists with basic interests in stratigraphy. According to their view, the more narrowly defined a genus or a species is, the more useful it will be in narrowly delimiting stratigraphic units. They contend there should be a name for every variation, and true taxonomic relationship (i.e., the nomenclatorial expression of morphologic scope) is disregarded. This giving of scientific names for every minor or local variant by some stratigraphers may help to solve some local stratigraphic problems, but it defeats the larger purpose of world-wide correlation which is the major interest of other stratigraphers. See Newell, 1956, pp. 66, 73.

And finally, coming back to the relatively lengthy discussion by Grant and Gale on this subject, they state some reasons in opposition to the splitting of genera (p. 89).

> A strange argument has recently been put forth to justify creating many new generic names and confining the older well-known names to small insignificant groups of species, namely that as the older names are usually of doubtful nomenclatorial status and their exact application is often subject to change, fewer species will be involved in the changes. In other words, it is suggested to make the unwelcome changes now to avoid the possibility of having to make them later. It might be noted here that if genera are used in a broad sense, such changes will usually mean merely a rearrangement of subgenera. Another argument to justify creating new generic names and limiting old ones is that the inclusion of various species in a genus should indicate that they are fairly closely related, whereas we often do not know whether they are or not, except that they appear to have a number of characters in common. If genera were smaller there would be less risk of including heterogeneous elements. However, if there were no genera, there would be still less risk, so the problem falls back again on the principle of the convenience of taking some risks in order to express relationships still imperfectly known, and the amount of risk that should be taken must be governed by the special circumstances of each case.

Undoubtedly the most unfavorable aspects of generic splitting have been the haphazard and irresponsible way in which it has been perpetrated in many cases. Some of the proposals of new genera and subgenera are found in faunal monographs. The faunal monographers too often do not know the range of variation of morphological characters within a family and, further-

more, do not know which characters are relatively stable and which are variable within a family. As an example, Iredale (1939, p. 302) erected *Tucetopsis* as a subgenus of *Tucetona* on such superficial and unstable characters as arrangement of the prionodont teeth on the hinge plate, the elevation of the adductor muscle scars, striations on the interior of the shell, and the shape of the crenulations on the interior ventral margin. *Tucetopsis* is just another meaningless name to be burdened with in the pelecypod family Glycymeridae. I can also see no reason for Finlay and Marwick's subgenus *Cucullona* (1937, p. 19) when *Latiarca* Conrad, 1862, is available; their attempt (p. 20) to distinguish between the two subgenera is certainly not convincing. Other examples could be brought forth, but these two should suffice. Such methods of erecting new genera and subgenera on shallow foundations, although some prove to be valid and useful, do more mischief than good.

Almost equally undesirable, however, would be the opposite extreme, an attempt to return to the methods of 150 years ago. The old Linnean and Lamarckian interpretations of generic names, although still used by many conservative workers, are so generalized—so lacking in preciseness of connotation—as to be uninformative. This deficiency can be illustrated by a comparison of the old, generalized (*sensu lato*), Lamarckian interpretation of *Arca* with the modern (*sensu stricto*) concept of *Arca*. The advantage of the latter is that it tells us a great deal about a species without benefit of a detailed description or picture or both. Another illustration is provided in the consideration of the old (broad) and modern (restricted) concepts of *Glycymeris*. (See below.)

In other words, a genus name should tell us in some detail the following facts about a species to which it is applied: its morphologic scope, its geographic distribution, its habitat, and something about its stratigraphic range if it has a geologic history. (I repeat, however, that a genus should not be split on the basis of the latter factors if a morphologic reason is lacking.)

Why, then, do some taxonomists still use only the Linnean and Lamarckian concepts of genera in their faunal studies? The answer is obvious: Many modern genera have been so finely delineated and are now so difficult (if not impossible) to distinguish from each other that the taxonomist seeking to allocate a species cannot find just one appropriate genus to the exclusion of all others. I.e., his species might fit the descriptions of several different genera. Even an examination of the type species of the various genera may provide no solution, for the species in question may have a few characters in common with each of several different type species but, in totality, be no more closely related to one than to another. The taxonomist solves or evades his problem in one of three ways:

1. He creates a new genus or subgenus for the species at hand, thus compounding the difficulties of future workers.

Arca, sensu lato	*Arca, sensu stricto*
Quadrate, subcircular, or rectangular in outline.	Rectangular in outline.
Longer than high or higher than long.	Longer than high.
Attached by byssus or free living.	Attached by byssus.
With or without byssus and byssal gape.	With byssus and byssal gape; byssal fibers enclosed in a sheath.
Living at shallow or moderate depths—0–2,500 ft.	Living at shallow depths—0–350 ft.
Living in tropical, temperate, or boreal regions.	Living in tropical or warm temperate regions.
Water temperature 38° to 80°F.	Water temperature 55° to 80°F.
Living on rocky, sandy, or occasionally even silty substrate.	Living on rocky substrate.
Glycymeris, sensu lato	*Glycymeris, sensu stricto*
Outline of valves subcircular or subquadrangular.	Outline of valves subcircular.
Radial ribs present or absent, raised or flattened, with or without superimposed radial striae.	Radial ribs flattened with superimposed radial striae.
Geologic range Cretaceous to Recent.	Geologic range Oligocene to Recent.

2. He arbitrarily assigns the species to an existing modern genus on grounds other than morphology—perhaps geography or stratigraphy—thus confounding the true purpose of taxonomy.

3. He resorts to vagueness, allocating the species to a time-honored and unprecise genus as established by Linné or Lamarck.

TAXONOMY AND THE PATTERN OF EVOLUTION

A knowledge of the progress of evolution in any group of organisms, even if the process is not wholly understood, is so intimately linked to classification that to ignore it courts taxonomic chaos. The next several paragraphs of this paper will be an attempt to show the broad pattern of evolution, in a very general and abbreviated way, and to show its essential relationship to taxonomy.

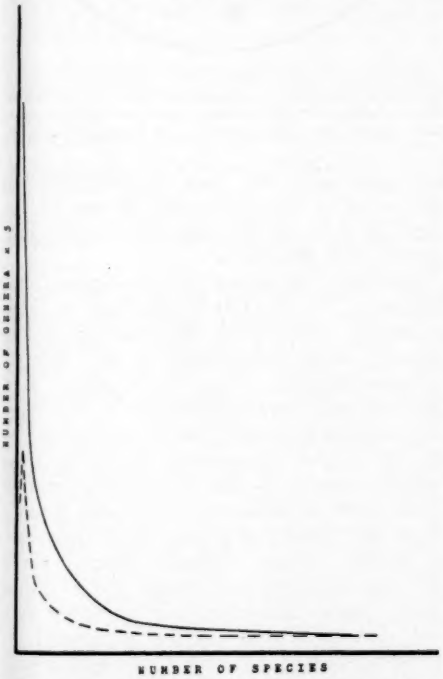

FIG. 1.—Two examples of the hollow curve of distribution; number of genera plotted against number of species in each genus of pelecypods. Vertical scale is approximately five times that of the horizontal scale. Dashed line—data taken from Deshayes (1835–1836); number of genera 97, of which 11 are monotypic, 15 have 2 species, largest genus has 135 species. Solid line—data taken from H. and A. Adams (1858); number of genera 327, of which 42 are monotypic, 31 have 2 species, 31 have 3 species, 27 have 4 species, 23 have 5 species, largest genus has 126 species. The Adamses' classification is a much more modern treatment.

Any taxonomist who has an interest in a group of animals, whether it be a phylum, class, order, or family, soon realizes from the standpoint of synthesis (the practice of putting things together by showing relationships or similarities; see Simpson, p. 22, 1945) that relatively few groups have numerous species; many more groups have few species. One has only to look at the relative size of the animal phyla to see this truism. On the basis of described living species, no animal phylum is more than one-tenth the size of the Arthropoda. There are some modest-sized phyla headed by the Mollusca, Protozoa, and Chordata. There are many more that are quite small; for example, the Entoprocta, Echiuroida, Ctenophora, and Chaetognatha all have less than a thousand described species each. Some groups of animals seem to have remained small in numbers of species throughout their geologic history as, for example, the scaphopods among the Mollusca. Of course, others are small today because they are apparently nearing extinction. The fact remains, however, that certain animal phyla have been much more "successful" than others, having a very large number of species, having many modifications of the basic body-plan, and having through adaptive radiation invaded a wide variety of habitats.

Much of this success has been attributed to the ability of the group to adapt itself to the environment. But when one examines families or genera one is likely to grasp the idea that the basic reason is most often genetic. J. C. Willis (1949, pp. 355–369) has noted that in groups of plants certain morphologic characters and certain combinations of morphologic characters are common within a particular family, while other possible combinations are rare or absent. Restrictions of morphologic scope are, of course, the basis for defining the family; hence, among the pelecypods, a specimen exhibiting only the characters of an arcid cannot be classified as a cardiid. But even

within the individual family there is a reasonably great range of possibility in the combinations of morphologic characters, and the important fact is that some combinations are far more "successful" (i.e., common) than others. For a hypothetical example, let us take the following possibilities of characters—*ABCD* and *abcd*—within a family having 200 described species.

A	*B*	*C*	*D*	combination occurs in	100 species.
A	*B*	*C*	*d*	combination occurs in	60 species.
A	*B*	*c*	*d*	combination occurs in	20 species.
A	*b*	*c*	*d*	combination occurs in	10 species.
a	*b*	*c*	*d*	combination occurs in	3 species.
a	*B*	*C*	*D*	combination occurs in	2 species.
a	*b*	*C*	*D*	combination occurs in	2 species.
a	*b*	*c*	*D*	combination occurs in	1 species.
a	*B*	*C*	*d*	combination occurs in	1 species.
a	*B*	*c*	*d*	combination occurs in	1 species.

The other possible combinations of characters either await discovery or have never existed.

A more concrete example of this is the type of ribbing found in the pelecypod family Glycymerididae. There are six possible combinations of radial ribs, or lack of them, within the family.

1. Flattened main radial ribs with superimposed radial striae. This type of rib pattern occurs in more than half of the 700 described species of glycymeridids and is exemplified by the genus *Glycymeris*.

2. Raised radial ribs with no superimposed radial striae. This type of radial rib, with some modifications, occurs in more than 100 species of glycymeridids and is typified in the genera *Tucetona* and *Grandaxinaea*.

3. Flattened radial ribs with no radial striae superimposed. This type of ribbing occurs in less than 50 species of glycymeridids and is typified by the genus *Pseudaxinea*.

4. Raised radial ribs with superimposed radial striae. This type of ribbing is very rare but is most often seen in some of the most primitive glycymeridids.

5. Radial ribs absent. Less than 10 described species of glycymeridids have this lack of ribbing, typified by most species of *Postligata*.

6. Primary ribs absent but secondary radial striae present. This is seen in a few species, probably less than 10, of *Glycymeris*.

For some unexplainable reason, concentric ribs are not present among the glycymeridids or, at least, species having them are as yet undiscovered.

The foregoing is admittedly a slight oversimplification of the rib patterns in the glycymeridids. The fact remains that the character of the radial ribs is one of the best criteria for dividing the family into genera and subgenera.

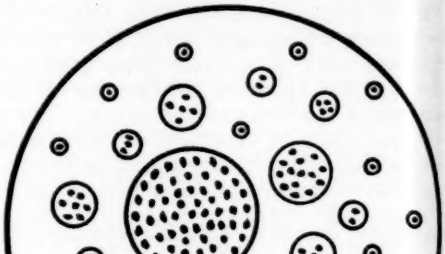

FIG. 2.—Typical distribution pattern of species within a family or subfamily. Outer circle represents family or subfamily; smaller circles represent genera and subgenera; dots represent species.

Another interesting morphological phenomenon in the Glycymerididae is that probably more than 99 percent of the species have crenulations on the interior ventral border. These crenulations may have an adaptive significance in that they may act as a supplementary locking device for the valves when closed. However, if the crenulations truly are an adaptive, rather than genetic, character, is it not strange that they rarely occur in the Limopsidae, a family having similarly shaped shells and the same type of hinge teeth? Additional genetic inferences may be drawn from the fact that although few glycymeridids lack radial ribs and even fewer lack crenulations, these two negative characters generally occur together in the same species, possibly indicating that they are genetically linked.

The phenomenon of genetic linkage is an indisputable basis for the commonness of certain combinations of morphologic characters and the scarcity of other combinations. If linkage is combined with one or more inversions, crossing over will be inhibited, and there is then little likelihood

that new combinations of morphologic characters will appear. Undoubtedly there are other genetic reasons, but the fact that there are more genes than chromosomes is certainly significant in the commonness of some combinations of morphologic characters and the scarcity or absence of others.

J. C. Willis in his book *Age and area* (1922) has been credited with the idea that the size of genera and higher categories is exemplified statistically by "the hollow curve of distribution." (Lotka, 1956, p. 313, calls the hollow curve a "hyperbola of the generalized type.") Briefly the idea of the hollow curve is this: If, for example, a family of 1,000 described species having 50 genera is examined, it is generally noted that there will be one, occasionally two, large genera containing perhaps half the species; the next genus, although fairly large, may contain only 250 species; the next will have about 150; then there will be many genera with a few species; and finally the pleurality of genera will be monotypic. When the number of genera is plotted against the number of species in each genus, a hollow curve is derived. Two hollow curves are shown in figure 1. Another hollow curve could be made by plotting the number of orders against the number of families in each order of mammals on the data given by Simpson (1945, p. 35). For other hollow curves see Ferris (1928, p. 115) and Willis (1949, pp. 260–261). For a good review of the hollow curve distribution see Chamberlin (1924, pp. 350–374).

Another way in which the distribution of a species can be depicted (figure 2) is by drawing a circle to represent a family. Within the large circle are smaller circles representing genera. Within each of the smaller circles are one or more dots representing species. It will be seen that most of the dots (species) occur in one or two large circles (genera), while most of the circles contain very few dots. This portrays the morphologic affinities of species within a family.

The significance of this short review of the hollow curve of distribution and related ideas is to show that in nature, from the standpoint of numbers of species, there are a few large genera, families, and groups of higher rank. At each level there is a much larger number of modest-sized groups and a still larger number of small groups. Most zoologists strive for what they term a natural classification, by which is meant the grouping together of animals on the basis of phyletic relationship, when known, and morphologic affinity—e.g., all gastropods in one large group, all pelecypods in one medium-sized group, and all scaphopods in one small group. It cannot be overemphasized that large, medium-sized, and small groups all are natural; and, returning to the subject of the Pelecypoda, any attempt to "equalize" the groups by splitting the vastly polytypic genera or lumping together the monotypic genera will ultimately discredit the science of taxonomy.

CONCLUSIONS

There must be a distinct morphological gap between a genus and its nearest relatives. To put it more pragmatically, if a species is morphologically assignable to more than one genus, the genera have been split too finely. The generic category is basically nothing more than a key for the morphologic grouping of species, just as the familial category is a key for the grouping of genera. In other words, if a key cannot be made to distinguish the genera from each other on morphologic grounds, then generic splitting has either gone too far or been poorly done, or both.

The matter of size has nothing to do with the case, except as Simpson uses the word—to connote morphologic scope; one genus may properly have as many as 1,500 species and another in the same family may have but one species. If the genus is an artificial category, as so many of the modern taxonomists insist, at least it should be a pragmatic category; otherwise it is useless and meaningless. Such statements as "for practical reasons the genus, to be a convenient category in taxonomy, must in general be neither too large nor too small" (Thorpe, 1940, p. 357) have little taxonomic merit, despite the fact that this statement has been quoted and, by implication, endorsed by Mayr (1942, p. 283) and Marwick (1957a, p. 12). I see no convenience

in arbitrarily assigning a quota of species to each genus. On the contrary, considerable inconvenience arises when, as often happens, the genera are delimited so finely and on such tenuous grounds that a single species is allocable to more than one genus. Also, from the standpoint of a phylogenetic classification, this artificial uniformity of size does not make any sense. The genus should stand for a concept of morphologic characters just as much as the species. The word "convenience" has been used with great regularity when discussing sizes of genera and higher categories in papers on taxonomy written in the past 15 years. I must ask: What is "convenient" about having genera all the same size? For whom is this "convenient?"

On the same page Thorpe decries "that *reductio ad absurdum* the monotypic genus." It would be interesting to see what he would do with the monotypic genus *Euloxa*, which various paleontologists have placed in at least three different pelecypod families. If *Euloxa* is so distinctive that even its family is doubtful, how could it be incorporated into another genus?

The problem, then, is to find a reasonable mean between the extremes of splitting and combining. When should a new genus be proposed? As a good "rule of thumb," if a taxonomist believes he has discovered an undescribed genus, having canvassed the literature in the field and found nothing like it previously described, the more difficulty he has in placing it in a family, the more likely it is that he has actually discovered an undescribed genus. This thought is certainly not an original one; most taxonomists use it either consciously or subconsciously.

Recent workers in the field of taxonomy would do well to read the chapter on Classification (pp. 108–127) in the late G. F. Ferris' excellent work, *The Principles of Systematic Entomology*, which was published in 1928. Ferris (p. 111) makes one point which every taxonomist should remember:

> To divide a genus artificially merely for the sake of "convenience" is the negation of scientific method. If there are actually five hundred species in any group so closely related that their relationships can best be expressed by keeping them in a single genus it were inexcusable from any scientific point of view to break up the genus merely to get smaller groups.

On page 123 Ferris makes another good point.

> It has already been indicated—but it may here be repeated with greater emphasis—that the *essence of classification is grouping*. The genus is essentially a *group* of closely related species. It is clear then that the tendency should be rather to hold species together—to conserve groups—than to separate them, unless that separation be the separation of *groups*. In other words, the monotypic genus, *in general*, is undesirable. This is not to say that monotypic genera should never be named, for there unquestionably are numerous forms so isolated from their nearest *known* relatives that to insist on keeping them attached to another group merely to avoid naming a monotypic genus would merely obscure the fact of their divergence.

There is no field of biology where good judgment and the application of common sense are more needed than in taxonomy.

ACKNOWLEDGMENT

The writer is particularly indebted to Dr. Edna Dudgeon of the Department of Zoology at Southern Illinois University for some ideas in genetics.

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ARAUCANIAN WITCHCRAFT

Witches, male and female, are potent, malevolent figures amoug the Araucanian Indians of southern Chile and Argentina. Each witch, or *kalku,* had his personal supernatural formula for doing evil, but occasional meetings are held in the forest for exchange of professional experiences. They may even trade secrets, which apparently are only variations of generally known formulae. The calling, however, is a perilous one for the practitioner.

The prevailing witchcraft customs are described by Sister M. Inez Hilger, Benedictine nun of St. Joseph, Minn, in a report recently issued by the Smithsonian. She carried out her studies while on a research expedition among the Araucanians.

A favorite point of attack, either for a fee or from pure malevolence, is a wheatfield. "The medium used," says the report, "is the mean of any 4-footed animal and/or eggs, which are bewitched and buried in the field." If a crop shows signs of failure there is little question on the part of the owner as to the cause of what must be done about it. An informant told the investigator: "They will then search in the field for meat—it is usually wrapped in a rag and can be found. ... If they [the owners] find the meat, they hang it over the edge of the fire in the *ruka* so that it will dry up. This will cause the one who buried it to dry up, also. Others stick it full of needles and lay it in the sun. The one who did the damage then feels the pain of the needles. ... Soon after that a terrible sickness will come over him. ... His entire body will tremble. If the sun shines, he will go out and stay in the hot sunshine [something not done by sane persons]."

According to another informant, "the kalku can use eggs in place of meat, if he wishes to. ... After the bewitched meat or eggs are in the field for several days, the wheat in that field either turns yellow or shrivels up. If they find the buried meat, they will hang it over a fire and cause the person who did the damage to shrivel up just like the wheat. ... But if the one whose field was injured does not wish to take revenge, ... he will throw the meat into the river." The suspected kalku may be a close relative or even a personal friend.

Once the meat is found the unfortunate kalku can be kept on tenterhooks, however, for as long as the intended victim wishes. As related by an Arancanian school teacher, an old woman was caught burying eggs and meat in the field of her brother-in-law. He immediately dug up the meat and hung it over a fire. The woman took sick with asthma and began to lose weight. She was sick for two years. By that time the man took pity on his brother, the woman's husband, and threw the meat into the creek. As it took shape slowly by absorbing the water the woman gradually got better and finally got well.

In another area a common form of revenge against the witch is to poke two sticks at right angles through one of the eggs found in a field and then hang the egg over a fire. The one who did the damage will become blind or have an arm paralyzed.

HERPETOLOGY.—*A new lizard of the genus* Leiocephalus *from Cuba* (*Squamata: Iguanidae*).

JERRY D. HARDY, Jr., University of Maryland. (Communicated by Doris M. Cochran.)

(Received July 25, 1958)

Barbour (1937) list four species of the genus *Leiocephalus* from Cuba. One of these, *carinatus*, is represented in the Bahamas by a number of subspecies and the Cuban population is now divisible into two races subsequent to the description of *aquarius* by Schwartz and Ogren (1956). The form *carinatus virescens* of the Bahamas has recently been introduced in the United States in the vicinity of Miami, Florida (Carr and Goin, 1956). The remaining Cuban representatives of the genus (*cubensis*, *raviceps*, and *macropus*) are endemic species which until now have been considered monotypic.

A recent examination of *Leiocephalus macropus* Cope indicates that it is more variable than previously supposed and that the population occurring south of the Sierra Maestra Mountains is worthy of subspecific recognition. The new form is to be known as

Leiocephalus macropus immaculatus, n. subsp.

Holotype.—U.S.N.M. 138412 collected in the vicinity of Ocujal, Oriente Province, Cuba, between August 29 and 31, 1956.

Paratypes.—A total of 41 specimens as follows: U.S.N.M. 138378–86, Ocujal, vincinity of the town spring, August 28, 1956; U.S.N.M. 138387, 138405–11, 138413–17, Ocujal, August 29–31, 1956; U.S.N.M. 138388–98, from sea level to 800 feet on the south slope of Pico Turquino (near Ocujal), August 31, 1956; U.S.N.M. 138399–404, Ocujal, near the town spring, September 1, 1956[1]; U.S.N.M. 81680, Río Magdalena, 1930; M.C.Z. 42384, South of Pico Turquino.

Distribution.—All but one of the known specimens have come from the vicinity of Ocujal, Oriente Province, Cuba. The single exception is from Río Magdalena (Fig. 4).

Diagnosis.—Generally similar to *Leiocephalus macropus macropus* Cope, but differing in the following details: Generally a lack of union between the internasals and the anterior median prefrontal (Fig. 1); a higher frequency of specimens with one or two median prefrontals than with three or more; the absence in males of a well-defined black shoulder patch (Fig. 2); a moderate proportional difference in the head shape of males (Fig. 3); an over-all dorsolateral pattern of almost uniform light brown as opposed to the more metallic shades and variable pattern of *macropus macropus*.

Description of the holotype.—A male, U.S.N.M. 138412, having a snout-vent length of 75.1 mm. Head length (snout to the anterior margin of the ear) 17.8 mm. Width of head 13.8 mm. Head depth, 10.9 mm. Interorbital distance, 10.6 mm. Distance between the nostrils, 3.1 mm. Eye diameter, 3.4 mm. Length of fourth toe, 19.8 mm. The tail is broken with only 10.9 mm of its original length remaining. The fore limb, when appressed, reaches a point 2 mm anterior to the hind leg insertion; while the hind leg, appressed, reaches the middle of the eye.

Head scales enlarged, smooth anteriorly becoming strongly striated toward the back of the head. Nasals and internasals in contact with the

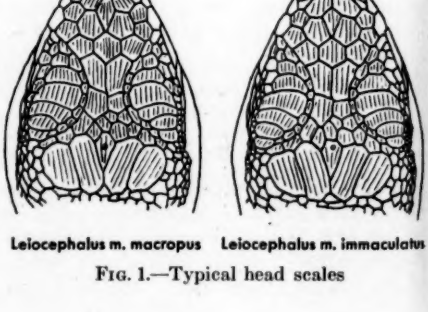

FIG. 1.—Typical head scales

[1] This much of the type series, including the holotype, was collected by the author and the following persons who accompanied him on a privately sponsored collecting trip during the summer of 1956: John E. Cooper and Clyde Prince, of the Natural History Society of Maryland; Anthony Picciolo, Department of Zoology, University of Maryland; and Donald Marlow of Alexandria, Va.

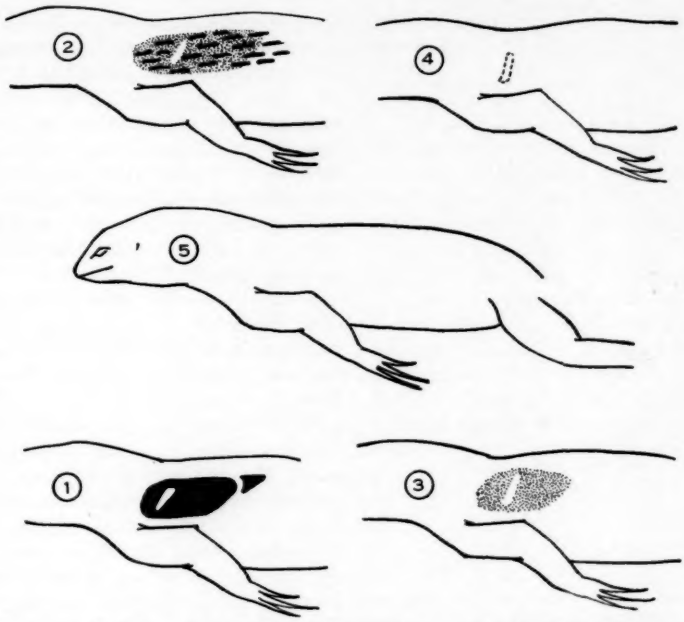

FIG. 2.—Diagrammatic illustration of the grading system used in studying differences in shoulder markings of male *Leiocephalus macropus*.

rostrum. Internasals oblique, broadly in contact with the nasals. Two median prefrontals, the anterior one kite-shaped, the second hexagonal and in contact with the frontals. Frontals much larger than the frontoparietals which are distinctly asymmetrical. Interparietal about equal to the anterior median prefrontal, bordered anteriorly by three small anomalous scales. Parietals in two pairs, the outermost broader than the inner. Circumorbitals 7/8; supraoculars 3/4. Upper labials 8/8, the third being somewhat longer than the rest. Infralabials 3/4, the second in contact medially with the second chin shield and the anterior-most sublabial. An extensive lateral nuchal pocket having a posterior skin fold which becomes continuous with the dorsolateral ridge. A well-developed lateral fold between the legs. Scales of the shoulder and neck region conspicuously small, but not granular, indistinctly keeled. Dorsal scales strongly keeled, ventrals smooth and much broader than long. Dorsal scale keels in longitudinal rows in the anterior dorsal region, but running obliquely on the posterior and lateral surfaces. Seventy-five scale rows encircle the body, and there are 63 scales along the middorsal line from the posterior margin of the parietals to a point approximately above the anterior lip of the anus. Subdigital lamellae of the fourth toes, $^{27}/_{29}$.

The color notes refer to the specimen after one year in preservation. Ventrally uniform bluish white except beneath the hind limbs and tail, which have a faint brownish hue. Laterally a broad band of dark brown about 14 scales in width. This band is darkest in the region of the neck and on the sides of the head. Dorsally there is a well defined broad band of light greenish brown mottled faintly with lighter brown. The raised middorsal scales are somewhat darker than the scales immediately adjacent to them. The head scales are light brown; but many of them have been lost thus giving the top of the head a grayish appearance. A small vertically oriented white bar occurs over the insertion of the right arm, but is missing on the left side. A similar white mark, more or less horizontally oriented, is located on the posterior margin of each thigh at a point approximately one fourth of the way from the base of the tail to the knee.

Variations in the paratypes.—The snout-vent length of mature specimens ranges from 44.6 to 83.3 mm. Females range from 44.6 to 65.2 mm

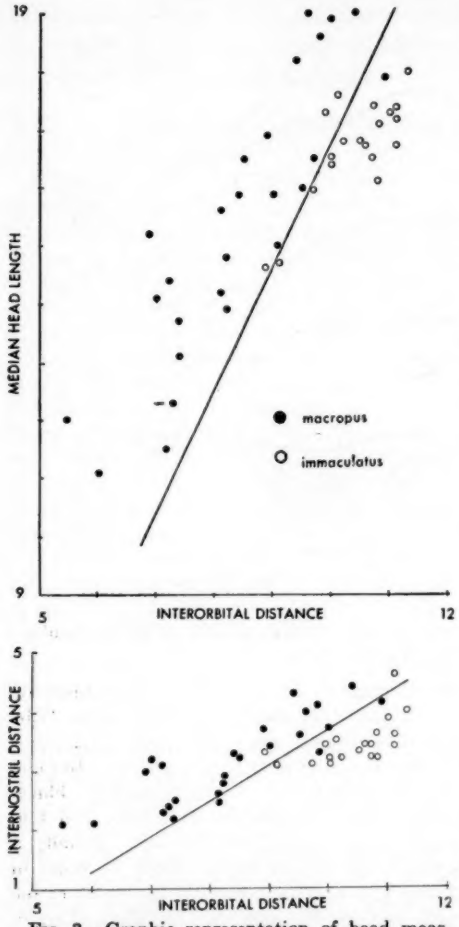

FIG. 3.—Graphic representation of head measurements of the two races of *Leiocephalus macropus* showing proportional differences in the males.

with a mean of 58.8; which the males range from 63.6 to 80.3 with a mean of 73.7 mm.

The number of subdigital lamellae of the fourth toe ranges from 27 to 32 in males with a mean of 28.7; in females the mean is 28.2 with a range of 23 to 30. The number of median dorsal scales varies in males from 58 to 71 (M 63.7) and in females from 59 to 68 (M 63.6).

The males are uniform brown dorsally, generally without, but occasionally with an ill-defined black shoulder patch. There is generally a faint middorsal brown spot or cross bar in the sacral and pectoral region. The throats and chins of adults are white or bluish; but young specimens tend to have them strongly mottled with gray. Occasional individuals have the chin very light blue, flecked with ivory. The females are more variable than the males in color and pattern, the dorsolateral color ranging from light brown to grey, frequently with much light cross mottling. The chins of females are usually more mottled with grey than are those of the males. All color notes refer to material which has been preserved for one year.

Comparisons.—The series of *immaculatus* has been compared to 45 specimens of *macropus macropus* in the collections of the United States National Museum and Museum of Comparative Zoology.

The two forms are most readily distinguished by the presence or absence of a dark shoulder patch. This is a sexually dichromatic character strongly developed in males and occurring only rarely as a poorly defined mottling in females. A grading system for various modifications of the shoulder patch was devised (Fig. 2) and male specimens classified accordingly.

Class	1	2	3	4	5	No.
immaculatus		1	5	15	2	23
macropus	20	8	2			30

If a separation is made between classes 2 and 3, 96 per cent of the *immaculatus* population falls between classes 3 and 4, while only 7 per cent of the *macropus* population is within this range.

The use of head scales as a taxonomic character in *Leiocephalus* is complicated by their frequently anomalous arrangement. The accompanying diagram (Fig. 1) shows normal head scale arrangements for the two subspecies. Only the median scales anterior to the frontals have been counted and these are collectively referred to as the median prefrontals, although some workers might consider the anterior one the frontonasal, and the posterior one, in some cases, might actually be a fragment of one of the frontals.

The degree of variation in head scales is of about equal magnitude in both sexes, so that data for males and females have been combined. Two head scale arrangements are recognizable; in the first the internasals are touched, thus slightly or completely separated by the anterior median prefrontal; in the other the internasals and the anterior median prefrontals are

not in contact. The first condition is referred to as internasal type A; the second as internasal type B. The two forms can be separated as below on the basis of this character.

	Type A	Type B
immaculatus	81%	19%
macropus	12%	88%

The number of median prefrontals varies considerable, but there is an observable shift from *macropus* to *immaculatus*.

Prefrontals	1	2	3	4	5	No.	Mean
immaculatus	1	25	15	2		43	2.4
macropus		5	33	2	2	42	3.1

Although the means are close it is possible to demonstrate an apparent difference between the populations based on this character through the employment of the method of Ginsburg (1938) for the separation of subspecies.

Prefrontals	1	2	3	4	5
immaculatus	.023	.581	.348	.046	.000
macropus	.000	.119	.786	.048	.048
Least overlap	.000	.199	.348	.046	.000

The raw data have been converted to percentage figures and the percentage of least overlap noted for each unit. When these percentages are summed and divided by two, the resultant figure represents the average intergradation between the two populations. This figure is 0.256 and falls very close to Ginsburg's percentage limit for subspecies (25 percent).

Intrasubspecific variations in the arrangement and number of anterior head scales occur frequently in both *macropus* and *immaculatus*, but these tend to follow basically recognizable patterns (Fig. 5). Note the intergradation represented in parts D, K, and L of this figure.

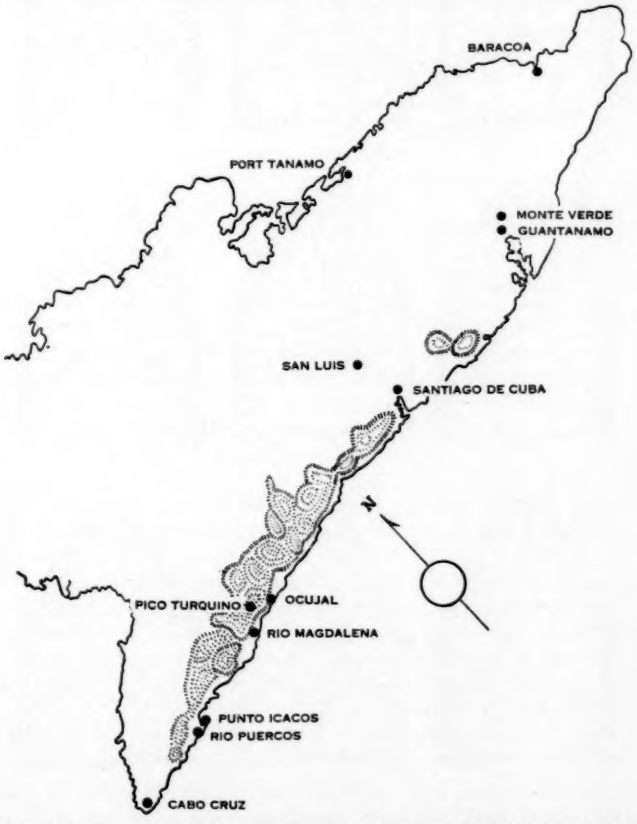

FIG. 4.—Map of Oriente Province, Cuba, showing localities mentioned in the text plus the Sierra Maestra Mountains south of which *Leiocephals macropus immaculatus* occurs.

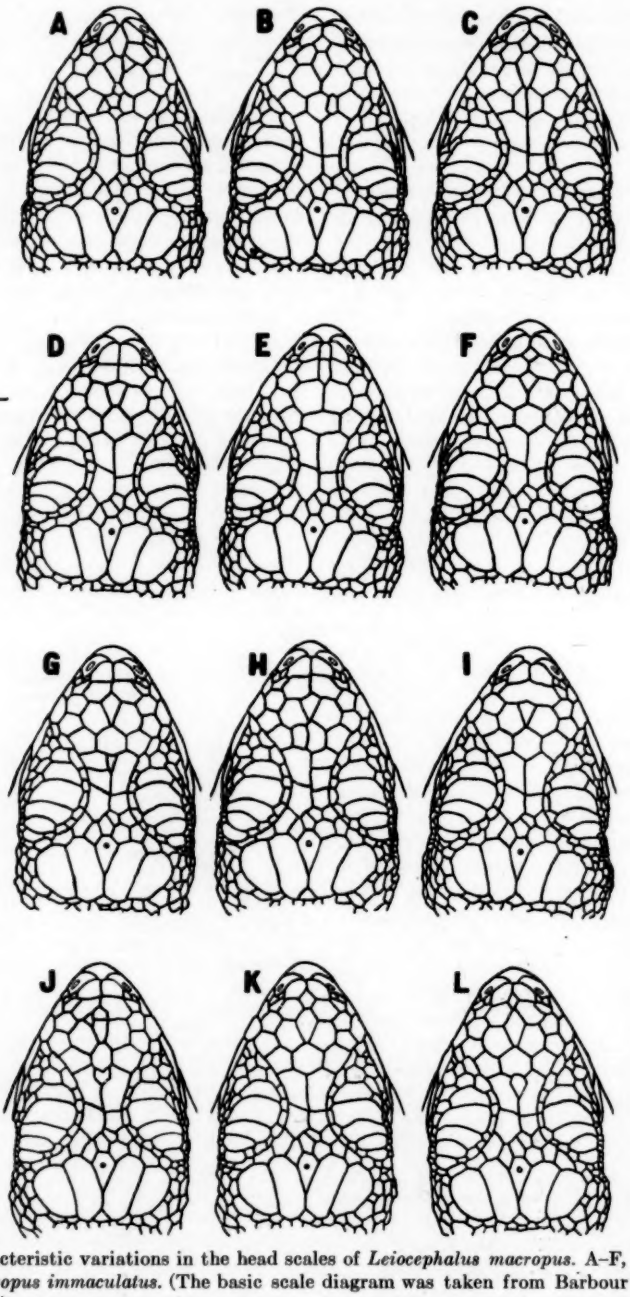

Fig. 5.—Characteristic variations in the head scales of *Leiocephalus macropus*. A–F, *macropus macropus*. G–L, *macropus immaculatus*. (The basic scale diagram was taken from Barbour and Ramsden, 1919, pl. 10, fig. 5.)

A series of measurements was made, three of which tended to indicate proportional differences in the head shape of males of the two forms. The data for these measurements have been plotted on scatter graphs and a line drawn in each case that would give maximum separation of the subspecies (Fig. 3). The percentages thus established are as follows:

	Above	Below
macropus	85%	15%
immaculatus	11%	89%

Internostril/Interorbital distance

	Above	Below
macropus	94%	4%
immaculatus	16%	84%

Median head length/Interorbital distance

No distinct proportional differences are observable in the females as indicated by the same data plotted for female samples.

Cochran (1941) points out that the chin and throat patterns of *Leiocephalus* are excellent characters for separating the numerous subspecies of *persontaus* occurring on Hispaniola. Although these characters are generally useful throughout the genus, they are of no diagnostic value in the present species since they are subject to both ontogenetic change and regional variation.

The type series of Leiocephalus macropus macropus *Cope.*—The 11 cotypes of *Leiocephalus macropus macropus* in the collection of the United States National Museum have not been included in the foregoing discussion owing to uncertainty as to the exact type locality. Cope (1862) in his original description of *macropus* gave the type locality simply as "Eastern Cuba."

Stejneger (1917) restricted this to Monte Verde on the basis of an old label in the jar with the cotypes. This label is no longer available. There is, however, a Monte Verde shown on the Military Map of Cuba for 1906, situated approximately 17 miles northeast of Guantánamo. It is reasonable to assume that this is the correct type locality, but there will always be some doubt.

U.S.N.M. 25819 best fits the measurements given by Cope (loc. cit.) and is, therefore, designated as a lectotype of the subspecies *macropus macropus*.

The cotypes in the U.S.N.M. agree with *Leiocephalus macropus macropus* as herein defined. Two of the specimens are males and have well-defined shoulder patches. Data for the other differentiating characteristics are as follows:

No.	Sex	Internasal Type	No. Prefrontals
12254A	♂	B	3
12254B	♀	B	3
12254C	♀	B	4
12254D	♀	B	3
25812	♀	B	3
24826	♀	A	1
25820	♀	B	3
25919	♂	B	3
25822	♀	B	3
25823	♀	B	3
25825	♀	B	3

The single cotype in the collection of the Museum of Compatative Zoology has not been examined.

Specimens examined.—Specimens used in this study include the type material of *macropus* and *immaculatus* as listed plus the following specimens of *macropus macropus*: U.S.N.M. 26769, Santiago de Cuba, C. W. Richmond, April 24, 1900; U.S.N.M. 29793, San Luis, W. Palmer, February 16, 1902; U.S.N.M. 29795, Baracoa, W. Palmer, January 30, 1902; U.S.N.M. 29847, Baracoa, W. Palmer, 1902; U.S.N.M. 59156–7, –60–61, Guantánamo Bay, Henderson and Bartsch, not dated; U.S.N.M. 80402–4, Port Tanamo, Parish-Smithsonian Expedition, 1930; U.S.N.M. 81671–2, 81674, Río Puerco, Paul Bartsch, 1930; U.S.N.M. 81681–4, Punto Icacos, Paul Bartsch, 1930; U.S.N.M. 81688–9. Cabo Cruz, Paul Bartsch; U.S.N.M. 138423, –25–30, Cabo Cruz, J. D. Hardy, Jr., September 5, 1956; M.C.Z. 11208, 11214, 12067–70, 14020–22, Baracoa; M.C.Z. 11436–38, Guantánamo; M.C.Z. 11435, Cabo Cruz; M.C.Z. 6922 (two specimens) Santiago de Cuba; M.C.Z. 47048–9, Baracoa (Joar); M.Z.C. 42518, El Junque de Baracoa.

Discussion.—The difficulties inherent in employing trinomial nomenclature to local populations are, at present, quite great due to the almost universally realized subjectivity of the subspecies concept and the complete lack of any real standards. At least three circumstances occur in the Cuban herpetofauna which result in apparently distinct populations within the same species. The first of these is the simple cline. Such a cline has been pointed out by Cochran (1941) who demonstrates a gradual increase from east to west in the number of ventrals in

the snake *Typhlops lumbricalis*. Likewise, it is becoming increasingly obvious that the two named subspecies of *Alsophis angulifer* represent such a cline with no distinct breaks clearly in evidence. The second circumstance involves highly variable species in which local populations seem unique. Thus several "new species" of *Hyla* have been named from Cuba all of which are currently in the synonomy of the quite variable *Hyla septentrionalis*. The third condition, and certainly the one to which a trinomial can most validly be applied, involves a number of quantitative and/or qualitative differences all of which break along approximately the same line in the species range, and in which a definite physiographic or environmental barrier can be correlated with the line of intergradation.

The last situation seems applicable to the population of *Leiocephalus macropus immaculatus*. The coastal area south of the Sierra Maestra Mountains is exceeding narrow and low and has been completely inundated by the sea within comparatively recent geological times. The flooding was apparently sufficient to make islands of the high mountain peaks and cause isolation of formerly continuous, homogeneous populations. Presumably these populations diverged slightly and with continued isolation may have evolved into full species; but with the receding of the sea they re-invaded the coastal region and various degrees of gene exchange with adjacent populations have since been possible.

The *immaculatus* population has remained relatively stable as a result of its habitat preference and limited vertical distribution. Thus far it has been taken only as high as 800 feet in the mountains, and probably does not occur much higher. Its habitat includes relatively open forest, meadow lands and the sandy *Coccoloba* forests just back of the beaches. The numerous rivers, some of them semi-torrential, which flow across the costal region, coupled with the dense vegetation along their banks, probably are important limiting factors in gene exchange between *immaculatus* and *macropus*. *Leiocephalus* is completely lacking along these river gorges and is replaced in abundance by various anoles, especially *Anolis argenteolus*. Allee et al. (1950) suggest that populations of animals surmount river barriers by invading their headwaters, thus going around the river. Since the habitat of *immaculatus* is limited to the lower slopes of the mountains, this course seems improbable, and the subspecies is at present relatively isolated.

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ICHTHYOLOGY.—*The status and distribution of the fishes of the family Microdesmidae in the Western Atlantic*[1]. C. RICHARD ROBINS and RAYMOND B. MANNING, The Marine Laboratory, University of Miami. (Communicated by E. A. Lachner.)

(Received July 24, 1958)

The family Microdesmidae encompasses a widely distributed but little-known group of tropical marine fishes. Placed by most workers in the suborder Blennioidea, Gosline (1955) has recently suggested their transfer to the Gobioidea. He also aligned *Gunnelichthys* with the Microdesmidae instead of with the Pholichthyidae or Chaenopsidae. Smith (1958) followed this arrangement and (1) synonymyzed *Paragobioides* with *Gunnelichthys*, (2) erected *Clarkichthys* for *Cerdale bilineata*, (3) considered *Clarkichthys*, *Microdesmus* and *Gunnelichthys* as subgenera of *Gunnelichthys*, and (4) changed the family to Gunnelichthidae (= Gunnelichthyidae). Earlier, Reid (1936) had reviewed the species known at that time and synonymized *Cerdale* and *Leptocerdale* with *Microdesmus*. Clark (1936), Myers and Wade (1946) and Kanazawa (1952) have also contributed to our knowledge of the family. Tentatively the writers persist in maintaining *Microdesmus* and *Gunnelichthys* as separate genera and thus the family name Microdesmidae. We do not comment on *Clarkichthys*.

At present, four species, *Microdesmus longipinnis* (Weymouth), *M. aethiopicus* (Chabanaud), *M. woodsi* Kanazawa and *M. floridanus* (Longley) are recognized in the Atlantic Ocean. Of the four, *aethiopicus* is known only from the eastern Atlantic and, since we can add nothing to Reid's account it will not be discussed further. The other three, from the tropical western Atlantic are especially interesting since they represent the extremes of body form in the genus, *longipinnis* the elongate form and *floridanus* the short-bodied form.

Our interest in the Microdesmidae was aroused by the capture of a specimen at night using a light at the dock of the Marine Laboratory, Florida (UMML) which answered equally well the descriptions of *longipinnis* and *woodsi*.

We are indebted to James E. Böhlke at the Academy of Natural Sciences of Philadelphia (ANSP) and to Leonard P. Schultz and Ernest A. Lachner at the United States National Museum (USNM) for the privilege of examining material in their care. Daniel M. Cohen loaned material from the Florida State Museum at the University of Florida (UF). Robert H. Kanazawa provided additional data on *woodsi* from his notes and Giles W. Mead provided the X-ray photographs of National Museum material. Material from the Alan Hancock Foundation (AHF) was examined at the Academy of Natural Sciences of Philadelphia where it was on loan to Dr. Böhlke. Loren P. Woods provided information on the holotype of *M. woodsi*.

Material examined.—Microdesmus longipinnis: Louisiana: USNM 64157 (1 specimen, 208 mm. in standard length), holotype. USNM 64158 (1, 171), paratype. USNM 107251 (1, 119). USNM 107753 (1, 186), USNM 117614 (2, 66–73). USNM 133654 (1, 46). Mississippi: USNM 121990 (1, 76). USNM 121989 (1, 56). AHF uncat. (4, 40–60). Florida: UMML 1901 (1, 170).

Microdesmus floridanus: Florida: USNM 102050 (1, 58), holotype. UF 7048 (1, 64). ANSP uncat. (4, 42–65). Bahamas: ANSP 80576 (1, 38), ANSP 81371 (1, 32), both from New Providence Island.

Microdesmus affinis: Panama: USNM 84300 (1, 98), holotype.

Microdesmus longipinnis (Weymouth)

Tables 1 and 3

Leptocerdale longipinnis Weymouth, 1910: 142–144, figs. 1–2 (description, type locality: Cameron, Louisiana; type species of *Leptocerdale*, good illustration).

Microdesmus longipinnis, Reid, 1936: 71–72 (characters, relationships). Kanazawa, 1952: 95 (characters, compared with *affinis* and *woodsi*).

Microdesmus woodsi Kanazawa, 1952: 93–95, fig.

[1] Contribution No. 214 from The Marine Laboratory, University of Miami.

TABLE 1.—FREQUENCY DISTRIBUTIONS OF FIN-RAY AND VERTEBRAL COUNTS OF *Microdesmus longipinnis* (WEYMOUTH) (* INDICATES HOLOTYPE OF *M. longipinnis*, † THE HOLOTYPE OF *M. woodsi* KANAZAWA). COUNTS SUPPLEMENTED WITH DATA FROM WEYMOUTH (1910:144)

Total dorsal elements							Anal rays					Pectoral rays		Dorsal fin ray over origin of anal fin			Vertebrae	
66	67	68	69	70	71	72	41	42	43	44	45	12	13	27/28	28/29	29/30	63	64
1	2	6*	5	7	3†	1	1	6*	6	5†	7	6*	8†	1	3	1*	1†	2*

TABLE 2.—FREQUENCY DISTRIBUTION OF FIN-RAY AND VERTEBRAL COUNTS OF *Microdesmus floridanus* (LONGLEY AND HILDEBRAND) (* INDICATES HOLOTYPE)

Total dorsal elements				Anal rays					Pectoral rays		Dorsal fin ray over origin of anal fin		Vertebrae
43	44	45	46	27	28	29	30	31	13	14	16/17	17/18	45
2	2	3*	1	1	—	1	2*	4	1	15*	3	2	1*

13 (description, type locality: St. David's Island, Bermuda).

Fin-ray counts and morphometric data are provided in Tables 1 and 3. Of the material listed above from which our data were taken only two are from the type series. The other 10 paratypes are at Stanford University (SU 2139) as noted by Böhlke (1953: 100). Dorsal- and anal-ray counts listed by Weymouth (1910: 144) have been added to Table 1. Despite the completeness of the description and the excellent figure of the holotype there has been considerable confusion about *longipinnis*. The body form depicted by Reid (1936: fig. 9g) is much too slim and is either based on a badly preserved specimen or was poorly executed. Similarly, Reid's (1936: fig. 12c) figure of the head of *longipinnis* shows too sharp a snout. The data on depth of body and head length as described by Weymouth (1910: 144) and by Reid (1936: 71) disagree. For example Weymouth expressed body depth in terms of total length which should yield a higher figure. However, the range of variation shown by him, 24½ to 33½, is lower than the 28.3 to 34.4 listed by Reid (based on the same material) in terms of standard length. The length of head presents a similar picture. The two specimens from the type series examined by us are in poor condition, their bellies much shrunken and the body flaccid. In elongate fishes such as the microdesmids, changes in body conditions will profoundly affect morphometric data. This is especially true when one attempts to express a small body part in terms of the very long body. In a fresh specimen (UMML 1901) the greatest body depth entered standard and total lengths 20.0 and 21.2 times respectively. Comparable data for head length were 12.6 and 13.3.

Since the collection on which Weymouth's description was based was made in 1906 considerable distortion of body form could have occurred. Significantly, Reid's data, taken many years later, show even more distortion. Weymouth's data are presumably the more accurate.

Reid's review indicates that there are correlated differences in fin-ray and vertebral counts and in body proportions for most of the species of *Microdesmus*. A species in such a group based only on a few proportional differences incites some question.

Kanazawa (1952: 94) gives the following data for *woodsi*: "Dorsal fin rays 71; anal 44; pectoral rays 13; ventral I, 3; vertebrae 63 (x-ray count)" and later states (1952: 95) that "this species may be distinguished from all others of this genus by the number of vertebrae, the number of dorsal and anal rays, and the position of the vent." However, the dorsal, anal and pectoral ray counts are within the variation of *longipinnis* (Table 1) and, although few data are available, these are probably shared by *affinis* as well. Kanazawa lists 63 vertebrae (including the terminal vertebra which bears the hypural plate). Weymouth (1910: 142–143) lists 62 vertebrae and the hypural plate or a total of 63. Reid (1936) attributes 62 vertebrae (28 body and 34 caudal) to both *affinis* and *longipinnis* but fails to mention if the hypural plate was included.

X-ray photographs were taken for USNM 64157, the holotype of *longipinnis*, USNM 107251, a specimen from Louisiana labeled *woodsi*, and USNM 84300 the holotype of *affinis*. Vertebral counts for these three specimens are 64 (31 + 33), 64 (30 + 34) and 63 (30 + 33) respectively. The count for the holotype of *woodsi* (63) is not an unexpected variant and is matched by one of the cotypes according to Weymouth's data.

Additional differences between *woodsi* and *longipinnis* were tabulated by Kanazawa (1952:

TABLE 3.—PROPORTIONS OF BODY PARTS OF *Microdesmus longipinnis* (WEYMOUTH) EXPRESSED AS PERCENTAGE OF STANDARD OR (*) HEAD LENGTH

Pre-anal fin length								Pre-dorsal fin length						Head length			Greatest body depth			Depth at anal fin origin		
46	47	48	49	50	51	52	53	9	10	11	12	13	14	6	7	8	3	4	5	3	4	5
1	—	—	2	1	—	1	1	2	2	—	—	—	2	2	—	2	1	1	2	2	1	1

Caudal fin length			Anal fin origin to midpoint hypural plate								Pre-vent							Eye diameter*						
5	6	7	47	48	49	50	51	52	53	54	45	46	47	48	49	50	51	6	7	8	9	10	11	12
1	2	3	2	—	—	2	1	—	—	1	1	—	1	1	1	1	1	2	—	—	—	—	—	1

95). Of them one stems from a clerical error for Kanazawa (in litt.) notes that the 1.3 measurement for the snout to anus distance in the column headed "*longipinnis*" should read 2.1; the latter figure compares well with the 2.0 for *woodsi*. The position of the vent varies about the midpoint of the body. Thus the pre-vent distance varies from 45 to 51 percent of the standard length and the distance from the vent to the tip of the hypural plate from 47 to 54 percent (see Table 3). The other differences as already noted result from poorly preserved specimens or are not of sufficient magnitude to be judged of specific value.

Thus we synonymize *M. woodsi* with *M. longipinnis*. *M. affinis* from the eastern Pacific differs in having a more restricted gill opening and in a more anterior placement of the anus. It is a close ally of *longipinnis* and additional material may show that the two forms are conspecific. Counts for the holotype of *affinis* are: dorsal-fin elements, 69, anal rays, 43, pectoral rays, 12, vertebrae, 63. Morphometric data expressed as percentages of standard length are: pre-anal fin length 54, greatest body depth 6, depth at anal fin origin 5, caudal fin length 6, origin of anal fin to midpoint of hypural plate 45, and pre-vent 53.

All the specimens of *Microdesmus* examined have 17 striated caudal rays. The number of striated caudal rays may aid in aligning genera and/or subgenera in the Microdesmidae.

Habits.—The Miami specimen was taken using a night light at The Marine Laboratory Dock and kept alive for a short time. The body and particularly the fins were flushed with pink, evidently a result of superficial blood circulation. It was very active and swam much like the worm eel, *Ahlia egmontis*, which was collected the same evening. Subsequent night-light operations failed to yield additional specimens.

Range.—*M. longipinnis* is known from the northern Gulf of Mexico in Louisiana and Mississippi to southern Florida and Bermuda. Although the material is limited, it is obvious that this little known bottom fish enjoys a wide geographic distribution. The species has not been recorded previously from Florida.

Microdesmus floridanus (Longley)

Tables 2 and 4

Cerdale floridana Longley, 1934: 259 (description). *Microdesmus floridanus* Reid, 1936: 60–62 (characters, figures, relationships). Longley and Hildebrand, 1940: 275–276 (characters, fig. 24, gill slit erroneously depicted). Myers and Wade, 1946: 165 (generic position).

As may be seen from Tables 2 and 4, *M. floridana* differs markedly from *longipinnis*. A short-

TABLE 4.—PROPORTIONS OF BODY PARTS OF *Microdesmus floridanus* (LONGLEY AND HILDEBRAND) EXPRESSED AS A PERCENTAGE OF STANDARD OR (*) HEAD LENGTH

Pre-anal fin length			Pre-dorsal fin length							Head length				Greatest body depth			Depth at anal fin origin			
50	51	52	18	19	20	21	22	23		14	15	16	17	11	12	13	10	11	12	13
1	3	4	1	1	1	1	2	1		3	2	1	1	1	3	4	1	2	4	1

Caudal fin length					Anal fin origin to midpoint hypural plate						Pre-vent			Eye diameter		
10	11	12	13	14	45	46	47	48	49	50	49	50	51	15/17	18/20	21/23
1	3	2	1	1	1	—	1	1	2	2	1	5	2	3	2	1

bodied form with few fin rays and vertebrae it is not surprising that it was placed in a separate genus. Any single character including the gill slit position appears to form a graded series when Pacific and African species are considered. All eight specimens examined possessed 17 striated caudal rays which seems constant for the genus *Microdesmus*.

Range.—M. floridanus is now known from the Dry Tortugas, the Florida Keys (Big Pine Key), and the Bahamas (New Providence Island).

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My dear collaborators, keep your enthusiasm, but let its inseparable companion be rigorous control. Do not advance any idea which cannot be proved in a simple and decisive manner. Cultivate the critical spirit. In itself, it is neither a provoker of ideas nor a stimulant to great things. It always has the last word, however.—PASTEUR.